110615

THE FOUNDRY

Vol. 43, No. 1 Cleveland, Ohio, January 1915 *Whole No. 269*

Electric Steel Castings Made on Large Scale

A Discussion of the Method of Operating This Furnace, Cost of Output, With a Description of the Otis Elevator Co.'s New Foundry

By H Cole Estep

CONSIDERABLE interest is attached to the new foundry of the Otis Elevator Co. at Buffalo, because it represents a serious attempt to make electric steel castings on a scale comparable with open-hearth practice. The foundry now has been in operation about six months and the results so far obtained from the electric furnace are satisfactory both as regards quality of product and cost of production. The cost of the electric furnace metal is particularly low because no difficulty has been experienced in melting machine shop borings and turnings which have a market value at present of only $5.50 to $6.50 per gross ton f. o. b. Buffalo. In this and other respects the furnace has an advantage over open-hearth melting. The new foundry, which is operated in connection with the Buffalo plant of the Otis Elevator Co., produces both gray iron and steel castings. The output includes castings that are necessary for the manufacture of freight and passenger elevator parts, such as motor frames, sheaves, sheave brackets, gear cases, cylinders, etc. The cupola in the gray iron department has a melting capacity of from seven to nine tons per hour and the plant is arranged for a capacity of 20 tons of gray iron castings per day. The steel department has a maximum capacity of approximately 20 tons a day. The building is 100 feet in width and 400 feet in length, one story high, with a basement under one end, 100 x 125 feet. The total floor space is 67,692 square feet.

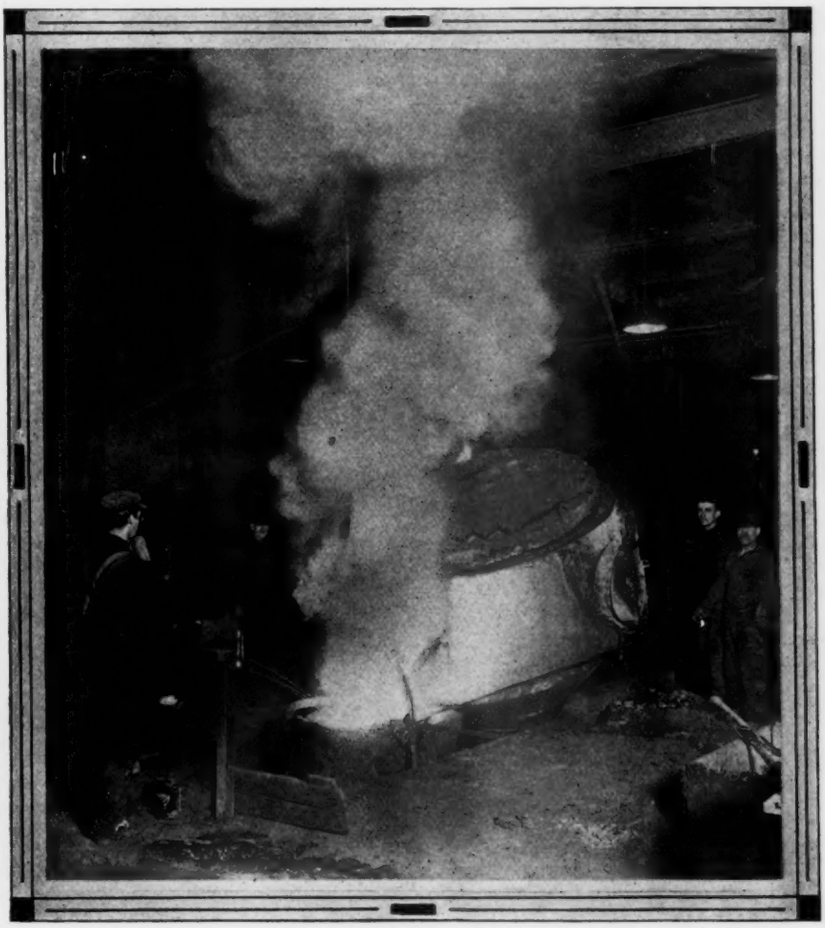


FIG. 1—POURING FROM THE ELECTRIC FURNACE AT BUFFALO PLANT OF OTIS ELEVATOR CO.

The electric furnace was furnished by the Metallurgic Engineering Co., Chicago, and is rated at three tons capacity. It is installed near the middle of the shop, as indicated in Fig. 10. Ample working space has been allowed on all sides of the furnace. The furnace is of the standard Snyder tilting type and is equipped with a single 6-inch graphite electrode. It uses single-phase current and its general arrangement is indicated in the accompanying illustrations. The shell is riveted steel plate and the furnace is lined with silica brick. The bottom is made with silica sand and the roof consists of silica brick specially made to form a self-supporting dome. The roof has an average life of 150 to 175 heats, and therefore it is carried in a removable cast steel ring. Two spare roofs are kept on hand and the change can be made in a few hours. This work is usually done on Sunday, so that no producing time is lost to the foundry. There are two charging doors, one on each side, of the breech block type, as indicated in Fig. 3. The electric current is led to the furnace through a graphite electrode, 6 inches in diameter, which enters on the top. The electrode is adjusted by a rack and pinion

FIG. 2—ELECTRIC FURNACE SHOWING SPOON AND TACKLE USED TO CHARGE HEAVY PIECES

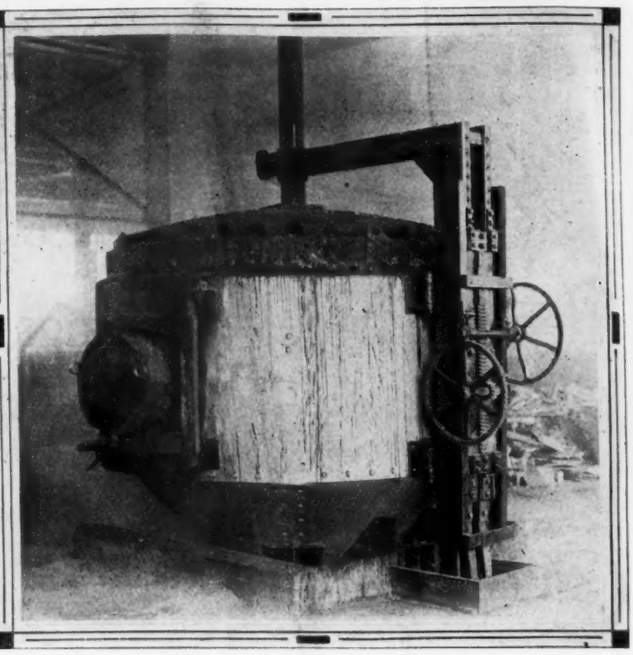


FIG. 3—REAR OF ELECTRIC FURNACE SHOWING MECHANISM FOR CONTROLLING ELECTRODE

gear at the back of the furnace, as shown in Fig. 3. The bath of metal forms the opposite pole, connection being made with the outside circuit through a steel contact inserted in the bottom of the furnace. A wattmeter mounted at the rear of the furnace is always in circuit and shows the power being consumed. The tilting mechanism, which is entirely beneath the floor, is of the customary rack and pinion type. It is driven by a five horsepower General Electric induction motor. The tilting motor is actuated by an ordinary railway type controller placed behind a steel plate screen in front of the spout of the furnace. A concrete ladle pit has been excavated in front of the furnace to receive the ladle when pouring. The working space around the furnace is paved with wood blocks furnished by the Ayer & Lord Tie Co., Chicago.

The electrical energy is furnished by the Cataract Power & Conduit Co. of Buffalo, the current being generated at Niagara Falls. It is delivered to the foundry at 2,200 volts, 3-phase, 25 cycles. In a subway behind the furnace two transformers are installed. They are Scott connected and supply the furnace with single-phase current at 220 volts. Suitable switches, meters and a reactance coil also are provided. Due to the energy losses in the coil and between the transformer and the furnace, the potential at the arc is about 195 volts. The furnace normally consumes 655 kilowatt-hours for a little less than two hours in melting a two-ton heat. The electrode cost is stated to be less than 70 cents per ton of steel and the refractories and repair cost less than 60 cents.

In order to reduce the cost of electricity arrangements were made with the

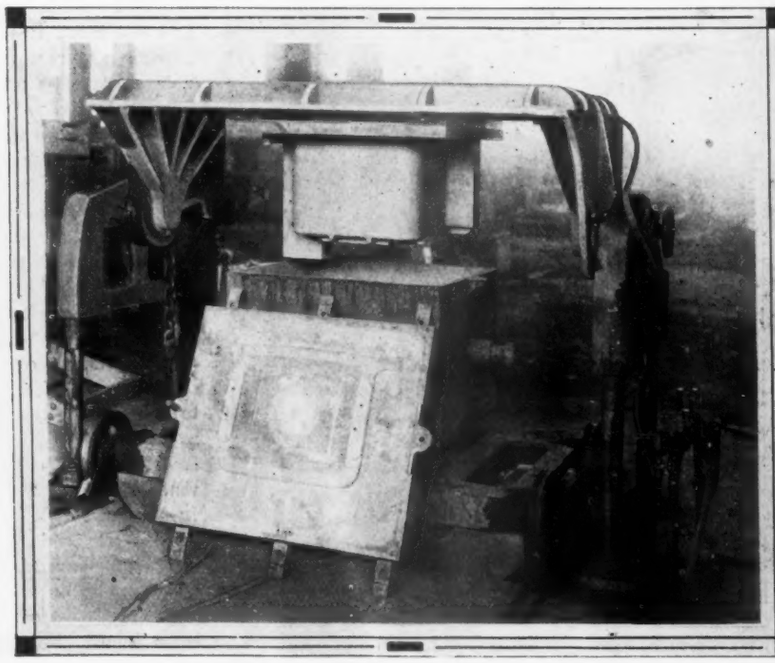


FIG. 4—ROLL-OVER JOLT MACHINE RIGGED TO MOLD MOTOR FRAMES

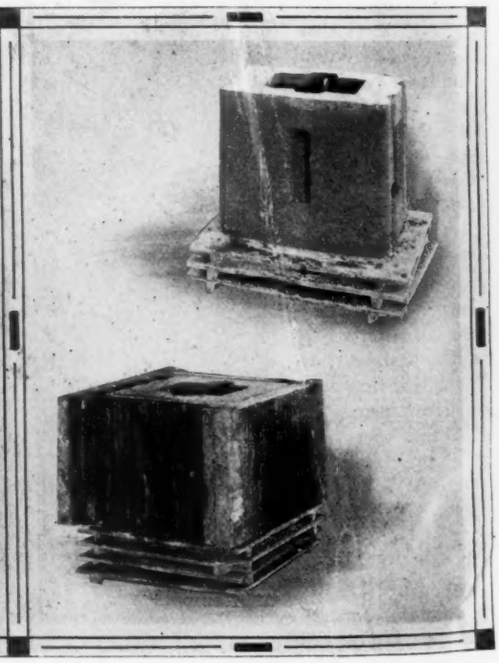


FIG. 5—CORES FOR MOTOR FRAME

605 F63 .A3 c.1

FIG. 6—CUTTING RISERS AND HEADS OFF MOTOR FRAME CASTING WITH OXY-ACETYLENE FLAME

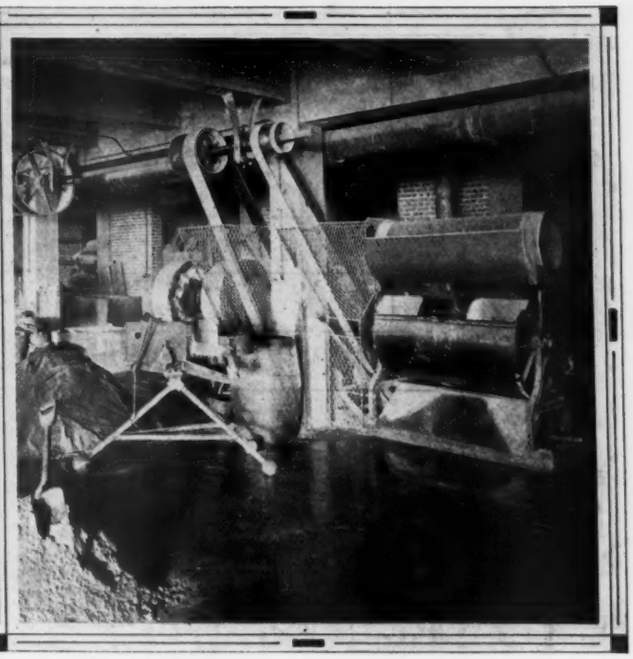


FIG. 7—SAND MIXING DEPARTMENT

power company to use the current only at night from 7 p. m. to 6 a. m. The molding, therefore, is all done in the day time, and a special gang comes on duty at 6:30 p. m. to operate the furnace and to take off the heats. This gang consists of 11 men, including a melter, who also acts as foreman, an electrician, a crane operator and eight laborers. This crew not only does all the work incident to charging the furnace, slagging off and pouring the heats, but it also shakes out the castings and cleans up both the steel and iron floors ready for the day gang. At the present time, four heats are taken off every night, aggregating nine tons in weight. Usually it requires about 2½ hours to melt the first heat, when the furnace is comparatively cold, the remaining heats being melted in somewhat less than two hours each.

The charge consists entirely of machine shop turnings and the heads, risers and returned scrap from the foundry. The proportions are 70 per cent turnings and 30 per cent returned scrap. The foundry scrap consists of fairly heavy pieces but the turnings, of course, are finely divided. The turnings have been allowed to lie out in the weather, and for this reason have accumulated a heavy coating of rust, which is reduced by charging charcoal with the metal.

The heads, risers and heavy pieces are charged first, using the long handled spoon shown in Fig. 2. The spoon is suspended from a light monorail by chain tackle as indicated in the illustra-

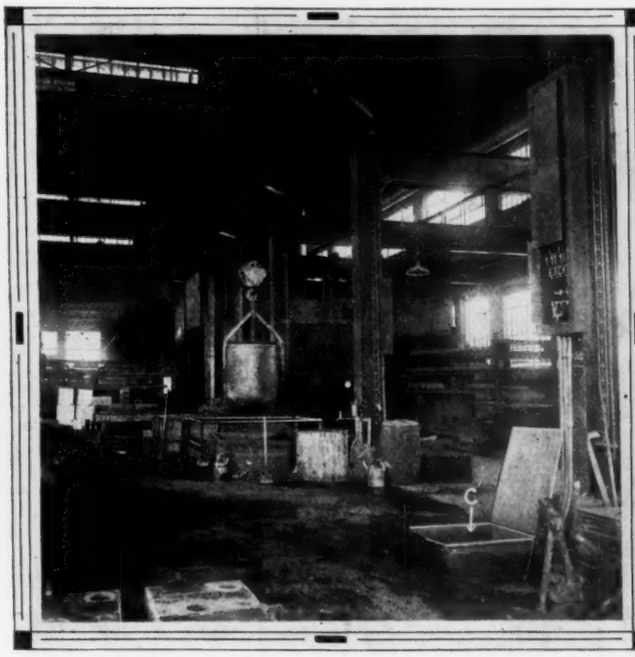


FIG. 8—A PORTION OF MOLDING FLOOR SHOWING HATCHWAYS AND CHUTES LEADING TO BASEMENT

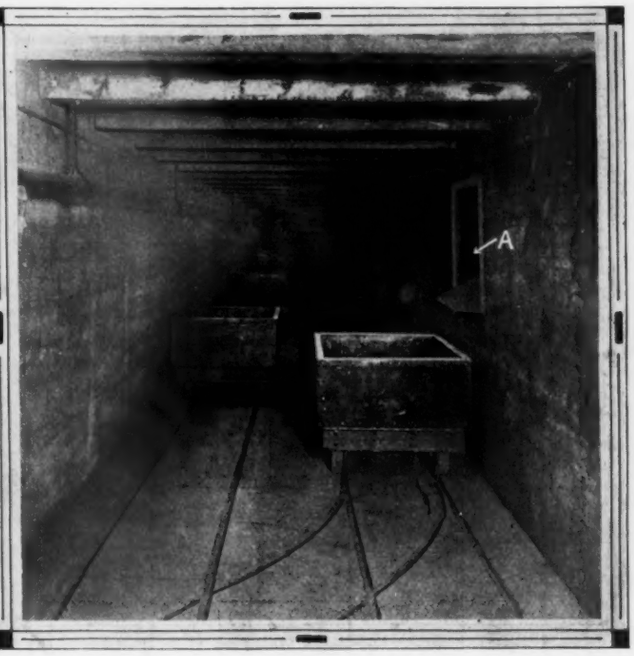


FIG. 9—SUBWAY UNDER MOLDING FLOOR

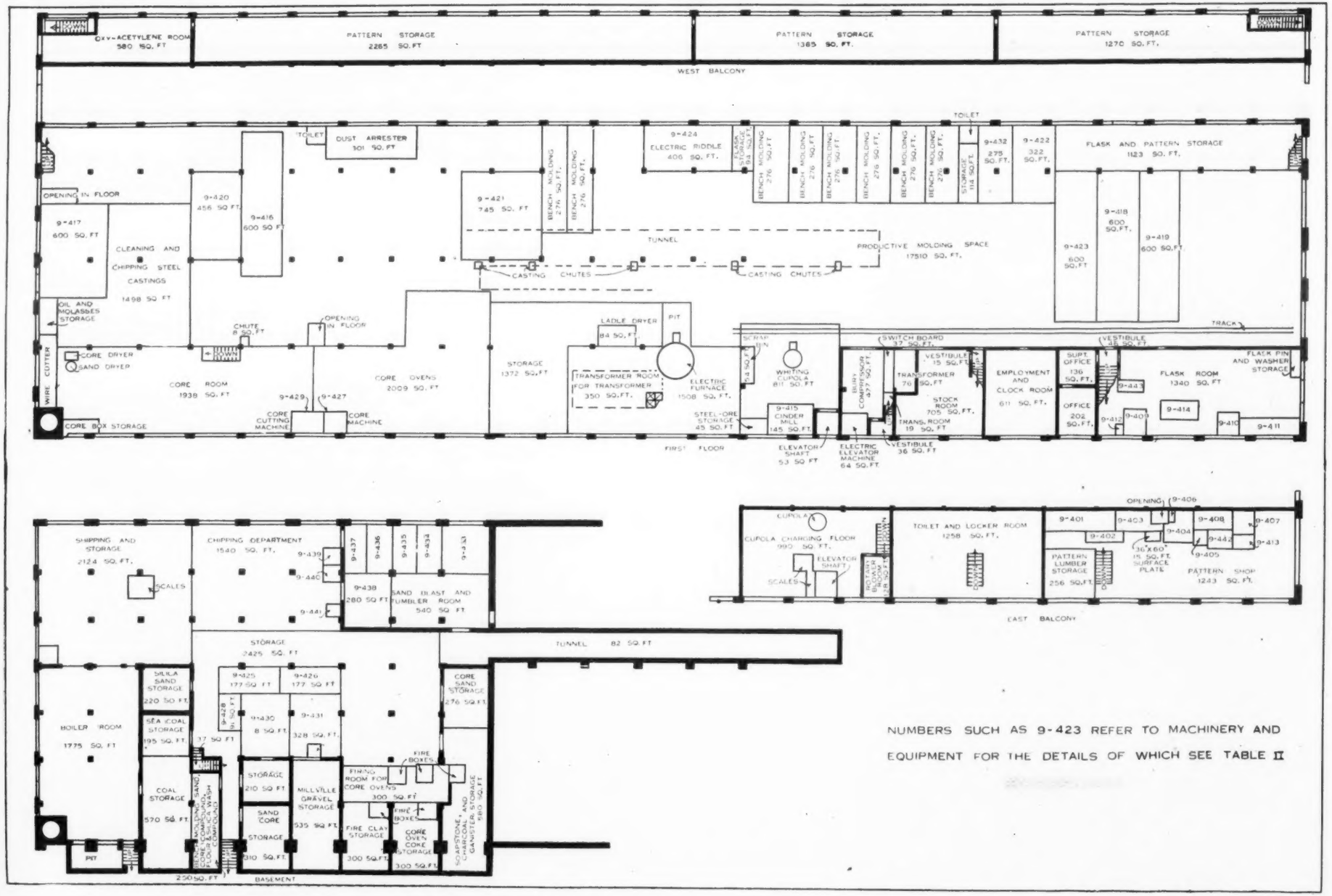


FIG. 10—PLAN OF OTIS ELEVATOR CO.'S FOUNDRY AT BUFFALO

tion. The turnings are charged on top of the heavy pieces, the furnace being filled up to and even above the charging door.

With the charge of scrap in the furnace, the switches are closed and the electrode is lowered until the arc jumps and a circuit is established. The position of the electrode during the melting process is regulated by referring to the wattmeter which shows the amount of power being consumed. When starting up cold, the melter usually stands by the hand-wheel for ten minutes regulating the arc to the full capacity of the furnace as the charge melts down. He then throws in a ratchet and the furnace regulates itself to the end of the heat.

The bath is handled practically as in standard open-hearth practice. The scrap is carefully analyzed and the charges are proportioned to produce the quality of steel desired. Near the end of the heat, alloys, ferro-silicon or ferro-manganese, are added as in ordinary practice to "kill" the steel and to bring the analysis up to the required figures. It is customary to pour test

Table I.
FLOOR SPACE.
The following figures give the floor area in detail:

	Square feet.
Entire floor space of floor	40,860
Entire floor space of east balcony.	4,782
Entire floor space of west balcony.	5,650
Entire floor space of basement	16,050
Transformer room	350
Total floor space	67,692

bars during the progress of the heat, although the operator soon learns from experience how to judge the composition of the steel from its consistency, color, etc., in the furnace. Typical analyses of the cast metal from the electric furnace are as follows:

	Motor frame castings. Per cent.	Machinery castings. Per cent.
Silicon	0.45 to 0.50	0.35 to 0.40
Manganese	0.10	0.40 to 0.450
Phosphorus	0.075	0.075
Sulphur	0.050	0.05
Combined carbon	0.18 to 0.20	0.18 to 0.20

The slag is made rather sticky and is drawn out of the charging doors before pouring with iron rabble hooks. If necessary, the slag is thickened by throwing molding sand into the furnace near the end of the heat.

When the bath is ready for casting, the melter takes his position at the controller located in front of the furnace and tilts the furnace so as to pour the molten steel into the crane ladle which has been lowered into the pit. It is a simple matter to control the pouring operation and requires only a cool head and a little practice in handling the controller. The ladles are of the usual bottom pour type found in steel foundries and have sufficient capacity to hold the metal from a 2½-ton heat.

The bottom contact is a steel casting which carries the current through the lining. The lower end of it is water cooled in order to protect the copper connections, but the upper end is solid and melts off flush with the lining. When the steel has been poured and the furnace cooled a trifle, a steel plug, or "button," is placed in the bottom of the furnace to displace the slag over the contact. It is said no operating trouble has been caused by this contact. Repairs to the bottom are made as in ordinary open-hearth practice. A contract has been let for the installation of a second furnace of the same capacity as the one described above.

In addition to the electric furnace, the Buffalo plant of the Otis Elevator Co. contains many interesting features. The general arrangement of the building, indicating the relation between the steel and gray iron departments, is shown in Fig. 10. One end of the shop is used for gray iron and the other for steel molding, the melting and core making equipment being arranged along the side as shown in Fig. 10.

A basement with a floor area of 16,050 square feet, provides ample space for sand handling and cleaning equipment. As shown in Fig. 10, a tunnel extends from one end of the basement under the molding floor. Tracks have been laid in the tunnel on which small industrial cars are operated. Fig. 9 shows a view in the tunnel. The cars may be lifted out of the tunnel by the cranes in the foundry through a hatchway at one end. It is customary, therefore, for the car to be placed anywhere on the floor that may be convenient and when filled with castings, it is picked up by the crane and dropped into the tunnel from which it is switched out to the cleaning room. Five spiral casting chutes are

Table II.
DETAILS OF EQUIPMENT IN FOUNDRY OF OTIS ELEVATOR CO.

Tool No.	Name of tool.	Average power per month in K. W. hours.	Sq. Ft. of floor space occupied.	Average air used per month in K. W. Hours.
9-401	Planer, 24-inch to 26-inch	200	143	25
9-402	Hand planer and jointer	166	38	25
9-403	Universal rip saw	100	80	25
9-404	Band saw	80	84	25
9-405	No. 3 Oliver wood trimmer	120	24	25
9-406	Double emery wheel grinder	95	7	25
9-407	Gardner Disc grinder	80	53	25
9-408	Pattern maker's lathe	111	72	25
9-409	36-inch band saw	80	62	25
9-410	Rip saw	100	56	25
9-411	Swing saw	80	108	25
9-412	Double emery wheel grinder	95	10	25
9-413	Drill press	80	32	25
9-414	Hand planer and jointer, 316-C-16	126	72	25
9-415	32 x 54-inch No. 3 water cinder mill	250	145	25
9-416	18-inch Pridmore molding machine	...	600	..
9-417	Newton cold cut-off saw	...	600	...
9-418	24-inch Tabor roll-over molding mach.	...	600	300
9-419	24-inch Tabor roll-over molding mach.	...	600	300
9-420	No. 2 combination jar ram roll-over pattern drawing swing-out molding machine	...	456	400
9-421	No. 406 Osborn direct draw roll-over jolt machine	...	745	600
9-422	13-inch plain power squeezer	...	322	300
9-423	30-inch hand roll-over machine	...	600	200
9-424	Hanna electric riddle with 110-volt motor	53	406	25
9-425	Hanna electric riddle with 110-volt motor	53	177	25
9-426	Hanna electric riddle with 110-volt motor	53	177	25
9-427	⅜ to 4½-inch stock core machine, Wadsworth	150	51	25
9-428	Blystone sand mixer and screen	400	91	25
9-429	No. 3 core cutting machine	150	74	25
9-430	60-inch sand grinder	800	328	25
9-431	60-inch sand grinder	800	328	25
9-432	Small sheave core machine	...	275	200
9-433	36 x 60-in. tumbling mill	158	225	25
9-434	30 x 54-in. tumbling mill } Central	148.5	124	25
9-435	24 x 42-in. tumbling mill } Iron	140	124	25
9-436	24 x 42-in. tumbling mill } Works	120	124	25
9-437	20 x 42-in. tumbling mill	110	124	25
9-438	Sand blast machine, Hoevel	135	280	1,000
9-439	Valley City grinder	250	33	25
9-440	Valley City grinder	250	33	25
9-441	Double emery wheel grinder	145	20	25
9-442	18-inch pattern maker's lathe	...	50	..
9-443	Drill press	...	32	..
	10-ton Shaw A. C. crane	976	...	20
	5-ton Shaw A. C. crane	538	...	20
	5-ton Shaw A. C. crane	538	...	20
	Dust arrester	400	301	20
	Electric elevator machine	380	175	20
	Wilbraham-Green rotary blower	520	128	..
	Whiting cupola	...	834	800
	Electric furnace	64,000	858	300
	Bury air compressor	7,000	477	..
	Oxy-acetylene generating	3,250	580	25
	Six bench vibrators	...	...	600
	Two air hammers	...	...	800

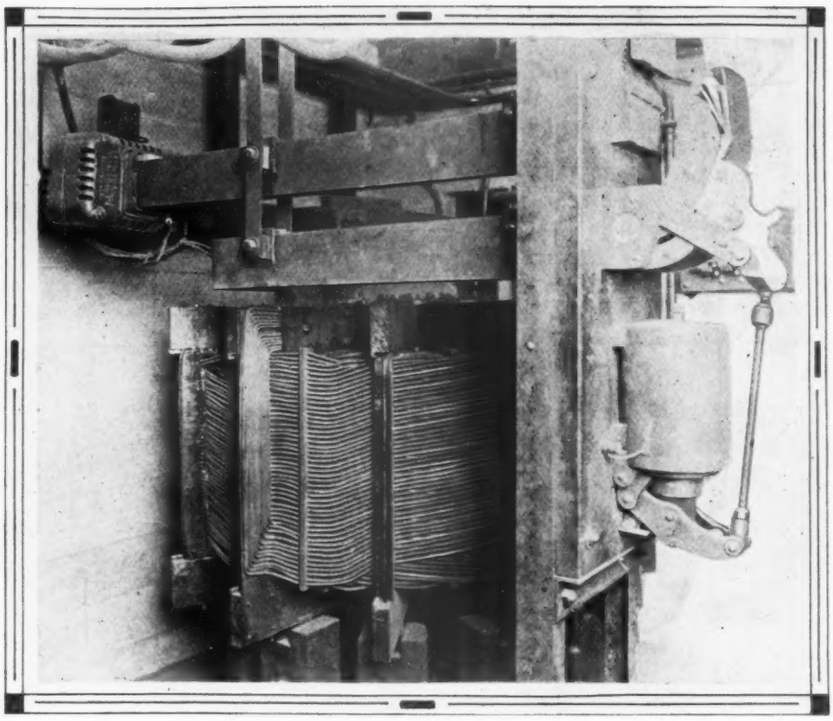


FIG. 11—REACTANCE COIL IN CIRCUIT WITH ELECTRIC FURNACE

also provided and castings which are not liable to breakage may be dropped through these chutes into cars waiting below as indicated at *A* in Fig. 9.

The sand bins which are in the basement may also be filled from the molding floor through chutes similar to that shown at *C*, Fig. 8. The sand bins also may be filled from railroad cars standing on the tracks in the yard outside the building.

The equipment in the sand mixing department, Fig. 7, includes a Blystone mixer, several Hanna electric riddles and two grinding mills which were built by the Otis Elevator Co. This equipment is placed in close proximity to the sand bins. The sand is distributed throughout the foundry in buckets which are handled by the traveling cranes indicated in Fig. 8. This illustration shows a bucket of sand being hoisted through the hatchway which connects the molding floor with the sand room below.

The crane equipment is unusually complete. The main bay is served by a 10-ton Shaw crane. In the steel molding end of the shop, the work of the 10-ton crane is supplemented by two 5-ton Shaw cranes which operate on parallel runways. The bench molders' stations along the wall opposite the electric furnace and cupola are served by a 1-ton floor controlled crane. A 7½-ton Shaw gantry crane has been installed in the yard for handling pig iron, coke, scrap, castings, etc.

In most respects the molding practice is standard. Figs. 4, 5 and 6 show how motor frames are molded, using an Osborn direct draw, roll-over jolt machine. The flasks are cast iron, 30 inches square, the drag being 24 inches and the cope 6 inches deep. After the mold has been rammed and rolled over, the drag is deposited on the transfer car connected with the machine as shown in Fig. 4, and the pattern is drawn. Fig. 4 shows the drag just after the pattern has left the sand. The cope is rammed by hand. Two men, a molder and a helper, operate the machine. The castings are made in several sizes, the one shown in the illustration weighing 800 pounds finished.

The cores, which are hollow, are made in dry sand. A finished core is shown at the right in Fig. 5; at the left in the same illustration, the core is shown as it appears just before the box is removed.

The motor frame castings are poured through a bottom flow gate and are provided with two shrink heads as shown in Fig. 6. This illustration also shows how the oxy-acetylene torch is used for cutting off heads and risers. The castings are cleaned by being tumbled in a mill.

The cupola for melting gray iron is situated alongside the electric furnace. It was furnished by the Whiting Foundry Equipment Co., Harvey, Ill., and is lined to 60 inches inside diameter. The blast is furnished by a Wilbraham-Green standard cupola blower direct connected to a 25-horsepower General Electric motor which runs 750 revolutions per minute. For recovering the iron in the cupola drop, a cinder mill manufactured by the Central Iron Works, Quincy, Ill., has been installed. The charging floor, which is arranged in the usual manner, has 990 square feet of working space. It is provided with suitable scales and is served by an elevator manufactured by the Otis Elevator Co. Ordinary gray iron machinery mixtures are melted, ranging from 2.25 per cent to 2.5 per cent silicon. The analytical work is handled through the Toronto office of the Charles C. Kawin Co.

The core room, which is situated in one corner of the shop, has a floor space of 1,938 square feet. It is equipped in the usual manner, including Wadsworth core making and cutting machines. The drying equipment includes four car type ovens, Fig. 8, and four five-drawer shelf type ovens. The ovens are fired with coke from the basement.

The general arrangement of the cleaning department in the basement is shown in Fig. 10. The equipment includes five tumbling mills furnished by

(*Continued on page* 15)

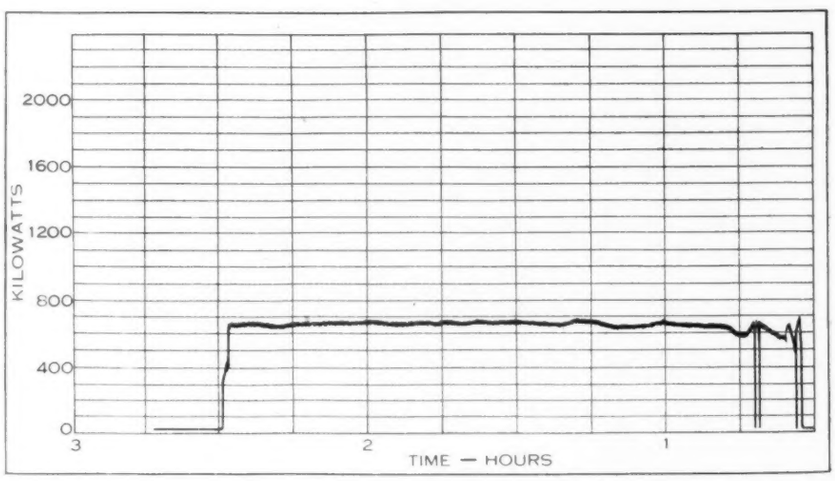


FIG. 12—ELECTRIC FURNACE LOAD CURVE FOR ONE HEAT

Revision of the A. F. A. Standard Cost System

This Introduction to the Foundry Cost Analysis Which Follows Discusses Briefly Simple Accounting Methods

By Harrington Emerson

COST accounting is in reality exceedingly simple. The object of cost accounting is to find out when, where and for what you spend your money. This is not of very much value unless you know how much you ought to have spent.

To know what standard expenses ought to be, to know what actual expenses were—this is the whole object, aim and use of cost keeping.

If every time you pay out money you look closely at the amount, know what it is for, and that it is neither too much nor too little, you have in reality a perfect cost accounting system. The whole object of any cost accounting system is to enable you to do this more easily.

Costs are a part of the necessary records of a business.

A record is very different from a report. A record is a statement of fact. A report is a statement of opinion. All records should have the following qualities.

Truthfulness;
Promptness;
Sufficiency;
Simplicity;
Classification; and perhaps
Permanence.

If a cost record lacks any of these qualities, it is not a good record. Many cost systems are reports, not records.

Truthfulness is the essential quality. If that is lacking the whole system is no good.

Promptness comes next. We want to know what our expenses are before we incur them, if possible; which means that we must have standards. Even if we do not know what our expenses are before we incur them, we want to know what they are before we pay them. Afterward it is too late.

In order to know our costs promptly, our system must be sufficient and simple; and it helps simplicity and sufficiency to classify the costs.

Bookkeeping makes the record permanent.

A cashier, in counting money, likes to keep the gold and silver and copper separate from the paper money. This is his first classification.

Next he separates the gold from the silver, and the silver from the nickels and coppers. He next puts the bills of each value in separate piles and the coins in separate piles. Then, and not before, does he begin to count what he has on hand or what he pays out. Even if you hand in to him $26.87 he grabs the big bills first.

One twenty dollar bill	$20.00
One five dollar bill	5.00
Three half dollars	1.50
Three dimes	.30
One nickel	.05
Two copper cents	.02
Total	$26.87

He has classified first and counted as he classified.

We must also classify all expenditures. There are three and only three absolutely distinct classes of expenditures.

Material expenses;
Personal payments (wages, salaries, fees);
Capital charges.

Keep these three classes entirely separate.

Never permit in the same bill both material and personal payments. Do not allow any bill to read "For iron, cartage and unloading, $87.00". It must read—

Five tons pig iron at 16 equals	$80.00
Cartage	6.00
Unloading	1.00
Total	$87.00

When it reads this way you can see right away whether $16 per ton is too much, whether $6 is too much for hauling, whether $0.20 a ton for unloading is four times as much as it ought to be.

Capital charges are a little more complicated. A separate account is always to be kept of money invested in the business. This investment is not an operating expense, but the expenditures necessary to maintain the capital are operating expenses. These expenses are only four in kind.—

Taxes,
Insurance,
Obsolescence and Depreciation,
Interest.

A very elementary system of accounting would be

Total capital investment		$100 000
Capital Charges.		
Taxes	$ 1,000	
Insurance	800	
Obsolescence	5.000	
Interest	6.000	
Total capital charges		$12,800

Total Materials

Pig iron, 1,200 tons at $16 equals	$19,200	
Coke, 200 tons at $5 equals	1 000	
Sand, 1,000 tons at $1 equals	1,000	
Total materials		$21,000
Wages and Salaries.		
Salaries	$16,000	
Wages	48,000	
Fees	1,800	
Total personal payments		$65 800
Total expenditures		$99,600

Costing per pound $0.0422 for 2,360,000 lbs. good castings.

There are all the elements of a good cost system here, but we can improve on it.

It is very desirable to distinguish between what are called direct and indirect expenses. A direct expense is one that can be charged directly to the product as iron, or coke, or cores, or sand, or molding labor or cleaning labor. Indirect expenses, as power, or maintenance, or supervision, or rent, cannot be directly charged to product. It is very desirable to know what expenses for materials, for persons and for capital charges are direct and what indirect.

It is, however, a widespread error and delusion that indirect expenses should come down in comparison to direct expenses.

All expenses should be as low as they can be made, yet have good operation. An absolute as well as a relative increase of indirect expenses may be the cause of better operation. If we can secure at double the salary a superintendent who cuts iron losses to 5 per cent, who melts 10 tons per ton of coke, who lowers molding and cleaning expenses, indirect expenses for his salary rise, but costs go down per pound.

It is not hard to keep direct and indirect expenses separate. A simple way of keeping perfect elementary accounts is to enter each item on a separate little sheet or card of paper.

We have four different colors each in two shades:—

White for capital investment.
Blue:—
  Dark for direct capital charges;
  Light for indirect capital charges.
Yellow:—
  Dark for direct materials;
  Light for indirect materials.
Red:—
  Dark for direct labor;
  Light for indirect labor.

Put all the white cards together,

A paper presented at the joint session of the American Foundrymen's Association and the American Institute of Metals, Chicago, Sept. 9, 1914.

both debits and credits, and you have the total capital investment, which must at any moment correspond with inventory.

Put all blue cards together and you have total charges.

Put all yellow cards together and you have total materials.

Put all red cards together and you have total personal bills.

Sort your dark blues, dark yellows, dark reds together and you have total direct costs.

Sort your light blues, light yellows and light reds together and you have total indirect costs.

Sort the light cards to the four indirect accounts—

Power,
Maintenance,
Supervision,
Rent,

and you have classified all your direct expenses. This will help you to find out whether per horsepower-hour or per pound of product you are paying too much for power, whether for amount of equipment or per pound of product you are paying too much for maintenance, whether per pound of product or number of men employed you are paying too much for supervision, whether per pound of product or floor space occupied you are paying too much for rent.

Anybody who can learn to play any card game, who has enough intelligence to know the difference between clubs and diamonds, between a king and a jack, knows enough to keep fundamentally correct elementary accounts. The more complicated chart presented by Mr. Mason is merely a development of the same system.

An Analysis of the Foundry Cost

By J K Mason

CONSPICUOUS in the galaxy of modern foundry needs, there stands out an all-prevailing one which in itself becomes probably the weakest element in the operation of making castings—the need for clear cut, immediate and accurate information as to the cost of parts produced. In an industrial period so clear visioned and scientific, such a condition is the more to be regretted in that it suffers still further by comparison with the vastly improved shop methods which have come to the industry. Any consideration of ways and means of bettering the situation becomes of vital worth when men realize that cost information carries the foundry to eminent success or to utter failure as that information is good or poor.

The only explanation that can cover the present lack of good cost figures, is the bonanza-like condition of industrial growth during the last half century. Our industrial fathers have been blessed with an abundance of material and labor, and profits have come with reasonable consistency. The country has witnessed a period of extensive economic expansion. Now, however, it has reached the turning point when all who would live must profit from the smaller things—must eliminate the little wastes in time, material and energy by a science that can come only from correct and sufficient knowledge of costs.

Four Natural Divisions

In presenting to you the accompanying chart, a few words are necessary in explanation. Foundry costs divide themselves into four natural parts:—

1.—The cost of iron before it is melted.

2.—The cost involved in converting it into a molten state.

3.—The cost entailed in the preparation of molds, of cores and in the pouring of metal; and

4.—The cost of cleaning and inspecting the output.

Such costs are cumulative. That is, as one pound of metal passes through the successive operations, its value appreciates step by step by reason of the newer and newer expenses that are laid upon it during its course of change from raw iron to finished casting.

Over in New England they make immense snowballs by rolling little ones over and over till enough layers of snow have adhered to make the size desired. The result is a cumulative one. In just this manner the initial raw metal cost may be conceived of as the germ or core, to which adhere the successive wrappings of operative costs which go to make up the total.

Net Cost of Raw Material

Beginning, then, with the raw metal, the analysis chart establishes a separate cost division comprised of costs for pig iron; home scrap; foreign (or purchased) scrap; and remelt (gates, sprues and floor scrap). From the total must be deducted whatever bad castings and remelt is returned. The resulting cost is that of the iron charged in the cupolas for the period covered by the figure.

In the proper sense, all metal handled comes from or returns to the stores department. It makes no difference what may be the size or organization of the foundry. Its material is stored; and though its storage space may merely be one end of the main floor, yet storage expense is present. Consequently charges or credits for metal taken or returned must be established at rates which include storage expense.

If you will examine the section of the chart entitled "Stores Department" you will see that metal costs start with the invoiced price. By deducting discounts and adding freight and demurrage charges, you have what is termed a direct cost of material.

There comes now the stores burden. It is comprised of the expenses for clerical help, office supplies, truckers and so forth occasioned by the stores department in its work, plus an overhead charge proportioned as will be explained hereafter under the title "Overhead Expense".

Direct cost of material plus this stores (or material) burden results in a gross cost of materials and supplies from which is established the charge per pound for iron and per unit for all supplies, taken day by day for foundry operation. All of which means, as just stated, that daily or weekly charges for iron and supplies must include not only the first price paid, but an additional charge to include a proportion of storage expense and overhead. Thus is determined net cost of raw material.

Cost of Conversion

There comes now the consideration of conversion costs and their structure. The chart so clearly outlines the details of conversion costs that there is little need for explanation. Suffice it to say that there are three chief elements:—

(a) labor and foremanship;
(b) materials, and
(c) overhead.

These comprise the entire expense involved in reducing the iron to a state capable of pouring into the molds. When added to the net cost of raw materials the result delivered is the cost in ladle, as shown.

Floor costs are the most complex of any involved in foundry work. Owing to the fact that cores and sand must be subjected to preliminary treatment before being available for use on the floor, floor costs must be divided into three sections, namely:

Core room,
Sand room, and
Molding room.

Core room and sand room costs must be assembled separately from all others and distributed to cores and sand produced before these materials can be charged against molding expenses. It might be questioned whether the operation of determining these preliminary costs is justified by conditions. Eminently it is. For cores and sand must be prepared in advance of the time when they are used by the molders; and, further, oftentimes both the core room and sand room turn out in a given period far more cores or sand than needed during the same periods for molds made. Therefore preliminary costs must be distributed individually to cores and to cubic yards of sand through separate records giving the individual outputs of those rooms.

Core room and sand room costs must, therefore, be segregated from all other costs. As cores and sand are drawn by the molders, proper charges must be made for each core taken, and for sand at a proper cost per cubic yard.

Floor costs proper are divided here into three general heads, namely:—

(a)—Direct floor cost,
(b)—Supplemental floor cost and
(c)—Floor overhead.

The last named does not include core room overhead; that being allotted to core room in a direct figure and brought to floor through the charges for cores used. Sand room is not charged with overhead because of its relatively small importance. Such overhead as might be proportioned there, is divided between core room and molding floor. Its entire expense is finally borne by cores through the core sand mixed, and by molds through the facing sand consumed in them. Green sand used on the floor is, of course, charged directly against floor expense as used.

Thus is floor cost prepared for combination with cost in ladle. The cumulative result delivers the cost in cleaning room; and here the analysis may pass to the question of cleaning costs.

Cost of Cleaning

Cleaning is a more or less simple consideration from the viewpoint of general costs. Its difficulties come with the act of distribution to individual castings. For the present however, it may be stated that in cleaning as in conversion and floor, three general heads comprise the entire figure. They are:—

(a)—Direct cleaning cost,
(b)—Supplemental cleaning cost, and
(c)—Cleaning overhead.

And when added to the cost in cleaning room just mentioned, the preparation of gross cost figures is complete in the term "Gross Cost of Finished Castings".

Now arises the proposition of determining costs per pound, both for gross output and for individual parts or symbols. The first is easy. From the records of output of good castings a gross poundage figure is determined, which, when applied successively to net raw metal cost, conversion cost, floor cost, cleaning cost, cost in ladle, cost in cleaning room and gross cost of finished castings, establishes the respective costs for each pound of gross good output.

Why Consider Only Good Castings?

Questions may be asked why only good castings are considered in all pound cost figures. Response is almost to be made in a Yankee answer. From what sort of output do you realize profits, good castings or both good and bad? Obviously only the good product is available for use or sale. Now, during the progress of the metal throughout the four divisions cited, certain work is expended upon certain castings which, in the final inspection, are suitable only as scrap for re-charging in the cupola. Work so expended costs money. But the cost of it can in no way be returned and melted over with the iron. Scrap iron ordinarily is of such mixture of iron, steel and alloys that even its raw value may fall below that of pig iron. The scrap value may be returned; but the value of work expended must be diverted to the iron which comes out in a form available for use or sale. Therefore, good castings must bear the burden. As greater skill is given to properly melting, molding, coremaking, etc., fewer bad and more good castings result. Proportionate costs per pound will then fall by reason of the presence of more good castings to bear the cost and of fewer bad castings to cause wasted effort. If ten men make ten castings and five of them are bad, the five good castings must bear the whole burden of cost, except such small sum as is taken back to stores in the scrap value of the five bad castings. This is the inevitable result of waste and inefficiency, and is one of the strongest of arguments against the cheap and unskilled employe. Nothing but saleable results can bear the burden of cost.

Let this point be illustrated. Suppose a day's records show:—

9,000 pounds pig iron @ 0.01 equals	$ 90.00
1,000 pounds scrap @ 0.0075 equals	7.50
Labor	50.00
Overhead	27.50
Materials	50.00
Total costs	$225.00

At the finish of inspection, records show:—

	Pounds.
Gates, sprues and floor scrap	1,000
Bad castings	9,000
Good castings	.....
Total	10,000

The result is an expense of $225 with no saleable return.

Suppose now that the next day's results show a total cost of $225 with an output of:—

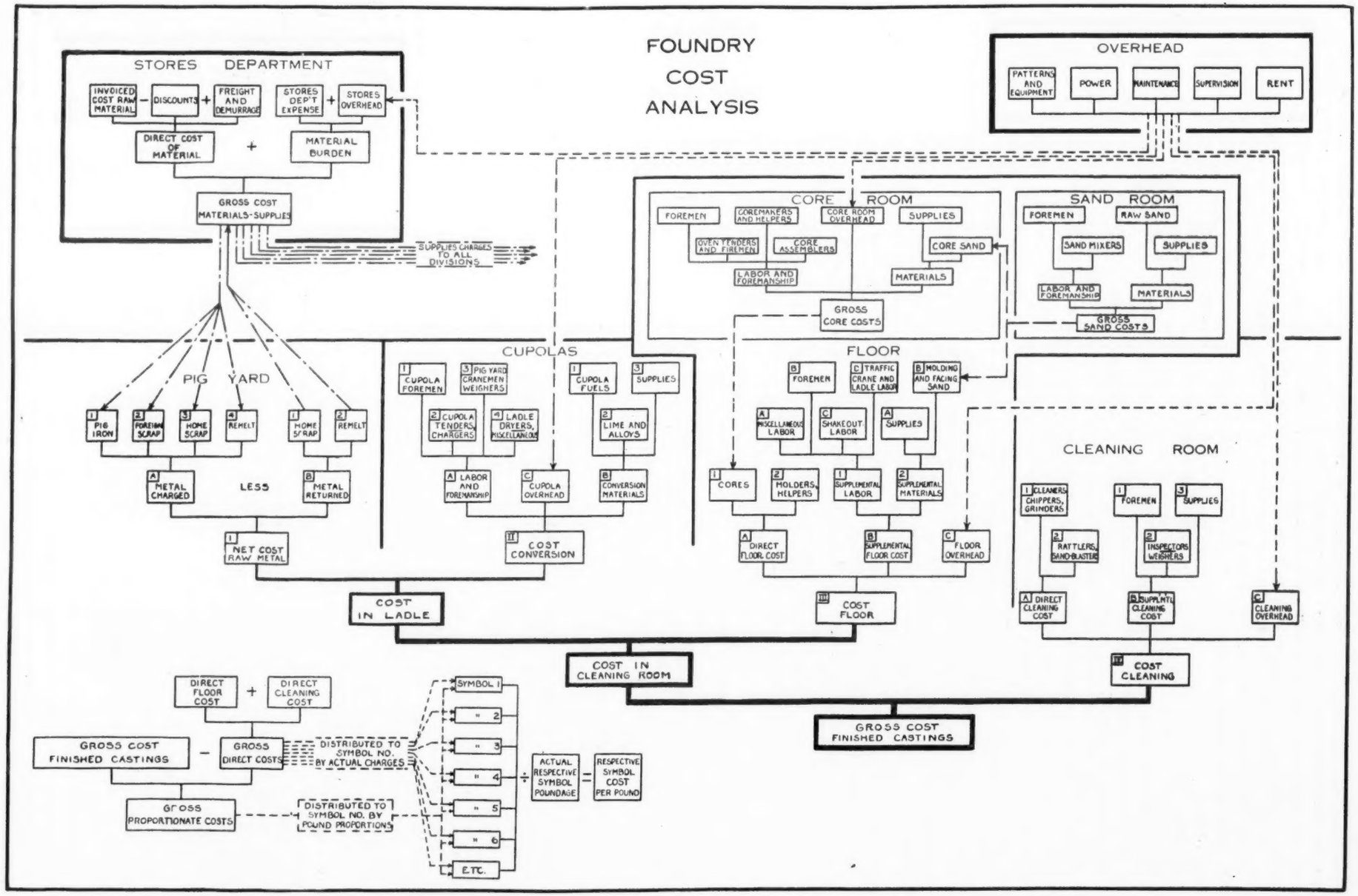
	Pounds.
Gates, sprues and floor scrap	1,500
Bad castings	3,500
Good castings	5,000
Total	10,000

On the latter day costs would equal $22 less scrap value for 5,000 pounds of remelt and bad castings at, say, $0.75 per 100 pounds, $37.50; leaving $187.50 to charge against the 5,000 pounds good output. This would mean a pound cost of $0.0375. But wait! What shall be done with the previous day's costs? There was an expense of $225 which may be reduced by the return to stores of 10,000 pounds of scrap at $0.75 per 100, $75, a net debit of $150. This must be cared for, and when added to the expense of the second day, brings the latter total up to $337.50. Divide this figure by the 5,000 pounds of good output which was the only achievement of the two days' effort expended, and pound cost jumps from $0.0375 to $0.0675. Where would be the result if those castings had been sold for $0.06? A total loss of $37.50 or 12.5 per cent of the sales income.

In summary then, it is folly to consider any result but the good output recorded at the finish of cleaning. Here and there foundrymen figure cost in ladle by dividing by the gross pounds melted, without consideration as to whether those pounds will be good or scrap, when finished. Such practice is eminently misleading, and it is strongly recommended that sinners mend their ways, or some day be submerged by the misjudgments which must result.

Distribution of Individual Castings

Having thus considered the problem of determining costs per gross pound produced, there comes in natural sequence the question of distributing those costs to individual castings—or symbol numbers. In the lower left



DISTRIBUTION OF FOUNDRY COSTS ACCORDING TO THE REVISED A. F. A. STANDARD COST SYSTEM

hand corner of the chart is presented a supplementary chart intended to explain in brief the operation involved in this latter problem.

Two separate distributions are necessary; the one by direct charge to a symbol for whatever cost may readily be carried to it, the second by proportionate or supplemental charge on a basis uniformly applicable to all symbols. The most uniform basis is eminently the pounds of metal consumed.

Four Detailed Costs

In examination of foundry operations it has been established that in general only four detailed costs can readily be charged direct to individual castings. They are the cost for cores; for molders and helpers; for cleaners, chippers and grinders; and for rattler and sand-blast tenders. In the general chart they are assembled as direct floor cost (III A) and direct cleaning cost (IV A). Uniting the two as a gross distributed cost, the supplemental chart shows the method of determining gross proportionate cost, by a deduction of the gross distributed costs from gross costs of finished castings.

First, dividing gross proportionate by the total poundage of good castings produced, a multiplication of the result by the gross pounds contained in the number of castings turned out under the several symbol numbers readily distributes the proportionate cost to all symbols.

The next operation is the distribution of "distributed" costs. This can best be accomplished by the use of what is termed a "service card", which is merely a ticket made out by the office and given to each molder or cleaner whenever his work is turned to the production or cleaning of a new casting. Time, wages and symbol numbers of castings are recorded on the service cards, which would be returned to the office and exchanged for new ones when the work is completed. Core service cards are merely special forms of the service card and would be issued to a molder as requisition on the core room when cores of any description were needed. Complete record as to the symbol number of the casting for which the core is to be used, together with costs and other needed data, are recorded on the card. And core cards would be returned each night to the office, to be distributed against the output of the period.

In distributing such charges, the service cards for the period are assembled and assorted by symbol number, the several kinds separately, and complete details of cost are compiled therefrom.

Many methods of recording detailed costs may be in existence. The one named is the only one which can be recommended for completeness and perfect flexibility. Through use of it, not only does the cost clerk find ease in distributing costs to divisions and to individual castings, but, further, the payroll clerk is furnished with simultaneous information as to wages through use of a carbon copy made out when the original is written up.

Aside from the detail of method, however, the essential point is that of individually charging out the items named, at the time when the work is done or the material is used.

Having been properly distributed, the resulting symbol costs are applied against the proper castings and combined with the proportionate costs already named. The only remaining duty is that of dividing individual casting costs by gross individual casting weights; which act will deliver individual total costs per pound for the several kinds of castings produced.

A word concerning cleaning costs should be entered here as supplement. Owing to the fact that frequently several kinds of castings must be rattled together to fill a drum, it is sometimes difficult to determine actual cleaning charges against respective castings. In such an emergency it is recommended that the castings be divided into classes by weight, and that no two classes be mixed in the drum when rattling. This done, the class cost may be recorded by whatever method is in use for reporting other direct costs and then be distributed by weight proportion to the individual symbols contained in the class. And in such instance, the fewer castings in any class, the more accurate the resulting figure.

Reverting to Material Burden

Reverting now to the matter of material costs, a natural question may arise as to the best method of apportioning material burden. After due study the only choice is to recommend a basis of direct cost per unit of material. The stores department is in reality a bank whose care is that of real money, though it be in divers shapes and conditions. Its work and responsibility is most likely to vary with the value of the material handled. In consequence any expense incurred is justly that which value causes—therefore value must bear the burden. Material burden should be established by apportionment on the basis of dollars represented by the material in stores; and the cumulative figure for direct and burden cost must unite in a single figure per unit of material delivered.

Assuming, for example, that direct cost for iron were 80 cents a hundred pounds, and that gross burden costs figured at a 25 per cent rate on the basis of gross direct costs, the charge that would carry against the foundry as gross cost of raw metal would total 80 cents for direct cost plus 25 per cent of direct for burden cost, or $1 per 100 pounds.

Costs for Supplies

Costs for supplies would necessarily be handled in similar fashion. So, with supplies being requisitioned by all divisions, proper material charges would automatically distribute themselves to cupola, to floor and to cleaning room—to proceed thence as a part of the complex figure for each division.

There remains the problem of proper distribution of overhead expense. Discussion of it calls first for a brief analysis of the structures of the overhead elements. Five divisions most naturally cover the entire subject, namely:—

(1) Pattern and equipment charges;
(2) Power expenses;
(3) Maintenance costs;
(4) Supervision charges;
(5) Rent;

which last includes building and grounds maintenance, real estate rentals, and other like costs which are ordinarily associated with a rental charge.

Comes the query: Why are not pattern expenses distributed as a direct charge against molding? The query calls for a word in supplement to the chart. In a jobbing foundry, where frequently special patterns must be made for each new casting put in the sand, pattern shop expense must be distributed to individual patterns just as, on the floor, molding costs are charged directly to individual castings. Similarly it would be accomplished by service card, whether for a jobbing foundry or for any other sort. In the case of a jobbing foundry, the gross assembled pattern expense for any individual pattern would naturally have to be carried immediately as a charge against customer for the casting made. In a non-jobbing concern individual pattern cost would be combined with other patterns and the whole charged into overhead for equipment on a depreciation basis.

In the event of such a charge, the pattern shop chart would take a form similar to that of the core room as shown on the chart; having its own overhead, and distributing its own

expense for labor and materials to completed pattern output. For both core room and pattern shop, a very logical basis for the distribution of overhead burden would be the number of man-hours expended in the making of the part by coremakers and core assemblers, in the one instance, and by patternmakers in the other.

Service card records would establish direct charges and would give the man-hours record needed as basis for the burden distribution.

The important point in the distribution of overhead is the basis on which charges to divisions are established. Equipment charges must be distributed in the form of daily or weekly cost for its use—such cost being determined in the manner of a depreciation figure.

Power cost most naturally rests upon the consumption of horsepower hours by the divisions—the cost per horsepower being determined through records of labor, material and overhead allotted to the power house. Records of consumption by meter are best, but where meters are lacking, estimated horsepower per division will serve.

Maintenance expense comprises materials and labor expended in repairs to equipment of the various divisions. In-so-much as such repairs are of lasting effect, it is not advisable to charge their cost directly against the division when made, but rather to charge daily maintenance expense to a controlling account from which would be determined each month a daily maintenance figure to be carried against output.

Supervision, an Uncertain Element

Supervision becomes perhaps the most uncertain element of all costs. It is comprised of certain administrative expenses not chargeable directly to any of the other overhead accounts. Salaries of general officers, liability insurance, general office expense and similar items are included. Care must be exercised, however, to guard against abuse of this account by using it as a general dumping ground for expense that the accountant is too lazy to care for properly.

Rent, as heretofore stated, is made up of all those expenses which would come under this heading if the building and ground used were not owned.

Supervision expenses may be charged to operation on a basis of time or material, depending largely on the circumstances surrounding the particular plant in question.

Rental charges should be proportioned in any event on a basis of floor space occupied. By recording square feet area in a division, rental costs are readily brought down to that division at a charge per square foot.

Recapitulation

Reverting, now, to a general examination of the problems of cost analysis, let the following simple facts fix themselves in your memories.

I—There are just three basic causes for expense:
  1.—Material,
  2.—Labor,
  3.—Capital charges.

II—Foundry costs are divided into four clear cut divisions:
  1.—Metal,
  2.—Conversion,
  3.—Floor,
  4.—Cleaning.

III—The operation of cost analysis is simply the separation of the three basic expenses into charges for each against each of the four divisions.

IV—The reporting of gross foundry cost is merely the reassembly of the analysis to tell the story of operation step by step as the details mass into a cumulative total.

V—The reporting of cost for any particular casting is but the selection of expense occasioned by that casting during its progress through the plant.

In so brief a summary of costs it is impossible to create a system of details that will care for the individual troubles of every foundryman. But it is possible to recommend a general scheme which may serve as the framework on which individual systems can develop.

In the rectangles contained under pig yard, cupolas, floor and cleaning room, the chart exhibits a Roman or Arabic numeral or a capital or small letter. If you will copy and assemble those symbols in order from pig yard to cleaning room, you will have created the following charge index:

I—Net cost raw metal.
  A—Metal charged.
    1—Pig iron.
    2—Foreign scrap.
    3—Home scrap.
    4—Remelt.
  B—Metal returned.
    1—Home scrap.
    2—Remelt.

II—Cost conversion.
  A—Labor and foremanship.
    1—Cupola foreman.
    2—Cupola tenders and chargers.
    3—Pig yard cranemen and weighers.
    4—Ladle dryers and mismiscellaneous.
  B—Conversion materials.
    1—Cupola fuels.
    2—Lime and alloys.
    3—Supplies.
  C—Cupola overhead.

III—Cost of floor.
  A—Direct floor cost.
    1—Cores.
    2—Molders and helpers.
  B—Supplemental floor cost.
    1—Supplemental labor.
      a—Miscellaneous labor.
      b—Foremen.
      c—Shake-out labor.
      d—Traffic, crane and ladle labor.
    2—Supplemental materials.
      a—Supplies.
      b—Molding and facing sand.
  C—Floor overhead.

IV—Cost cleaning.
  A—Direct cleaning cost.
    1—Cleaners, chippers and grinders.
    2—Rattlers and sand blasters.
  B—Supplemental cleaning cost.
    1—Foremen.
    2—Inspectors and weighers.
    3—Supplies.
  C—Cleaning overhead.

These are your analysis accounts. If for every element of expense, whether material, labor or capital charge, you provide a proper index from the above table when the expense is incurred, your costs will automatically divide themselves so clearly that any boy can assemble them to accord with the chart. In his introduction to this survey, Harrington Emerson suggests the value of a color distinction between the service cards for material, labor and capital charges. Such a scheme has been applied in problems of cost analysis, and has proven to be of extreme assistance, particularly when the system has had to depend for its results upon the work of cheap clerical help.

There are many ways in which the cost index and color scheme can be refined. For instance, were you to assemble all the red labor cards for a day or week, your payroll could be made up directly from them. Similarly could stores consumed be reported from the yellow material cards; and capital charges be recorded from the blues.

By adding to index IIC, IIIC and IVC the Arabic numerals 1, 2, 3, 4 and 5, it is possible to determine how much of an equipment, power, maintenance, supervision or rental charge is borne by each of the cupolas, the floor and the cleaners.

The St. Louis Foundrymen's Club held its regular meeting at the Marquette hotel, St. Louis, Saturday, Dec. 12. Thomas H. Ross, of the David Rankin Jr. School of Mechanical Trades, delivered a very interesting address on pattern-making, which was freely discussed by the members present. A committee was appointed to present names for nomination at the January meeting.

Novel Tests of Malleable Cast Iron

Interesting Data Regarding the Strength of Malleables After Removal of Skin

By Enrique Touceda

IT IS a well-known fact that the softest and most ductile constituent in any iron product, is ferrite, carbonless iron. If, through the aid of the microscope, one is shown a specimen of iron or steel that has been properly polished and etched for that character of examination, and it is seen that in the structure ferrite predominates, it can be predicted that the material from which the specimen was taken is soft and ductile, directly in proportion to the amount of ferrite present. If the structure is wholly ferrite, and this is uncontaminated by slag or free carbon, it can be predicted that the metal is of maximum softness and ductility.

The structure of good wrought iron consists practically of ferrite, due to its containing but an inappreciable amount of carbon, but the uniformity of the structure, as can be seen by reference to the photo-micrograph, Fig. 1, enlarged 63 diameters, is somewhat interfered with by the presence of slag particles that cannot be entirely removed from the iron during the process of manufacture.

Portions of a paper presented at the annual meeting of the American Foundrymen's Association, Chicago, Sept. 8-11.

It must be conceded that commercial wrought iron is both soft and ductile, and that its structure consists practically of ferrite, throughout which are irregularly distributed particles of slag, so that if we obtain some other product of similar structure, aside from the fact that for the particles of slag there is substituted some other impurity equally inert, we should logically expect to have a product of similar physical qualities.

The object of annealing in malleable work is to separate the hard carbide of iron into its two constituents, iron and carbon, and the resulting structure must consist of ferrite and free carbon, failing which, the anneal has not been properly accomplished. It may be accepted then, that the structural composition of properly annealed malleable iron is made up wholly of ferrite, but with the exception of the ferrite in the rim, all of this constituent is contaminated with more or less free carbon, the preponderating amount of ferrite containing but very little, and the lesser amount containing it in highly concentrated form, these carbon patches, as they can be appropriately called, being uniformly distributed throughout the area of the section, as can be seen by reference to Fig. 2, enlarged to 63 diameters.

In short, with two exceptions, if the slag of wrought iron and the free carbon of malleable iron be left out of consideration, the structural composition of wrought iron and malleable iron are identical. One of the exceptions is that the ferrite of the malleable iron is higher in silicon than that of the wrought iron; but if the proper authorities be consulted it will be seen that they state that such an amount of silicon as may be found in commercial malleable iron does not render the ferrite less ductile, nor does it have an influence to render more coarse the crystallization. This then can be set aside as having no bearing on the case. The other exception results from the presence in the ferrite of the contaminating free carbon, which is present in too small an amount in a great part of the ferrite to affect its true physical properties to any appreciable extent, but which I anticipate must lessen its strength and ductility where it occurs in the ferrite in concentrated form, as shown in the patches referred to.

What I desire to make plain at this time, however, is the fact that if the two steps in the malleable iron process have been properly conducted, even if

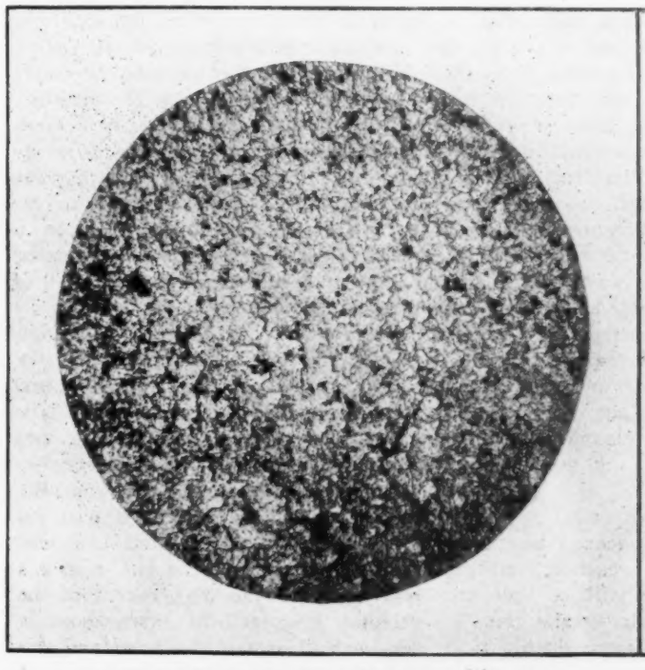


FIG. 1—SECTION OF A WROUGHT IRON BAR

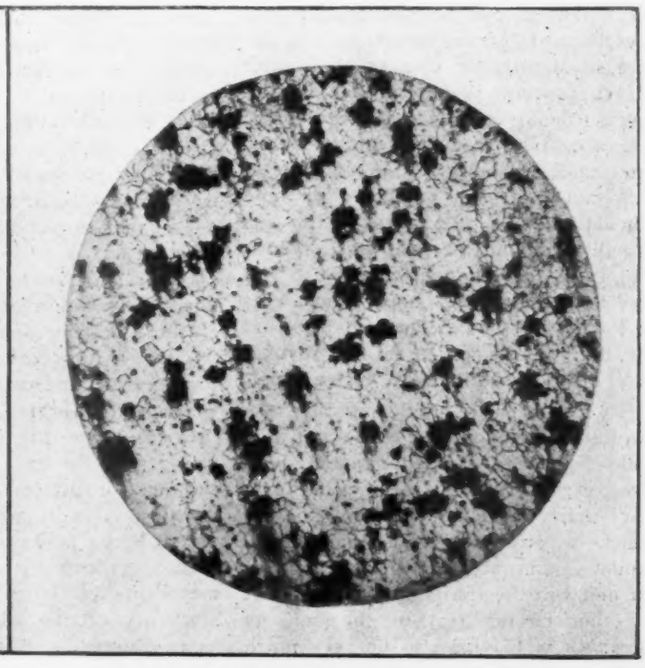


FIG. 2—SECTION OF A MALLEABLE IRON BAR

in a casting there be a section 3 inches square, it will be found that the structure of this section is uniform throughout; which fact I have proven to my complete satisfaction on numerous occasions.

How the Skin Differs From the Core

Let us now take up the question of the so-called skin of malleable iron castings, and see in what particular this skin differs from the rest of the metal in the casting. If the annealing process has been arrested at the exact moment when the last trace of free or pearlitic cementite in the casting has been broken up into ferrite and free carbon, there will be seen under magnification, around the edge of the casting a rim about 1/32-inch deep of practically carbonless iron, due to the perfect elimination of the carbon to this depth. As a matter of fact such a rim as I describe exists in any piece of rolled steel or steel casting, so that in this particular a malleable casting does not differ in this respect from rolled steel or steel castings.

FIG. 3—TEST WEDGES OF MALLEABLE IRON SHOWING GREAT DUCTILITY

The structure in the balance of the section is very uniform throughout, except that it can be noticed that the patches of concentrated carbon increase slightly in size as the center of the section is approached, the increase being very slight indeed. If we now take ¾-inch round test bar, and calculate the area remaining after the rim has been machined off, and then the area of the metal in the rim, it will be found that the first amounts to 4.442 square inch, while the latter amounts to 0.07 square inch; the metal in the rim being 15.8 per cent of that in the core, as the rest of the metal is sometimes designated.

It has been pointed out that the structural composition of the rim as a rule is ferrite, uncontaminated with free carbon, and it is a well-known fact that annealed ferrite will not exceed in strength more than 50,000 pounds per square inch. If the amount of metal in the rim is but 15.8 per cent of that of the rest of the bar, its strength would have to be very much higher than the strength of annealed ferrite in order to bring the strength of the bar as a whole to 41,000 pounds per square inch, the average strength of commercial malleable iron. Assuming for the sake of illustration, that the metal remaining after the rim has been machined off will stand 30,000 pounds per square inch, which is certainly far from being worthless material, the metal in the rim must stand as high as 98,838 pounds per square inch in order to bring the bar as a whole to a strength of 41,000 pounds per square inch, the average strength of commercial malleable iron. Also 98,838 pounds per square inch corresponds to the strength of a 0.50 per cent carbon steel. If the statement is correct, that after the rim has been removed the remaining material is very inferior and lacks ductility, then the figure that I have placed as its strength (30,000 pounds per square inch) is too high, and the metal in the rim must be called upon to stand a strength in excess of 98,838 pounds per square inch, that is, a strength equal to a 0.60 per cent carbon steel.

An elongation of 10 per cent in 8 inches is by no means uncommon in good malleable iron, and if the above remarks on the relative strength of the metal in the rim and core do not make the statements I am questioning absurd enough, let us dwell for a moment on the condition that must exist in a malleable test bar that yields an elongation in 8 inches of 10 per cent.

It is conceivable, and a fact that must be acknowledged, that a rim of metal having a strength in excess of that in the core, can add greatly to the final strength of the bar, but how under the sun can the metal in the rim affect the elongation, unless its ductility be less, not greater, than the metal in the core? If it be of less ductility, then it will start to check as the limits of its capacity to stretch without fracture is reached, and the metal in the core will continue to stretch until the bar breaks; but if, as is claimed, it is more ductile than the metal in the core, then the metal in the core will stretch until it can no longer do so, when the metal in the core breaks, and that in the rim likewise, for obvious reasons, though it must be admitted that the metal in the rim had not at the time reached the limits of its capacity to stretch.

If my reasoning is correct, and I feel quite confident that such is the case, any record of elongation on a malleable iron test bar expresses in exact terms the elongation of the metal in the core only, as the metal in the rim is capable of further stretch. Records of elongation then, on malleable iron test bars, are a direct measure of the ductility of the metal in the core of the bar.

Defects in Test Bars

The writer, particularly during the past few years, has had a great deal of experience in the making of physical tests of malleable cast iron, and he has noticed that defects nearly always exist in bars such as are usually made for tensile test, due to unsoundness caused by shrinkage, or faulty contraction as the case may be. Such defects obviously are in the majority of cases located at the center of the section of the bar, and nearly always at the central region of the bar's length.

I wish to stick to my brief, and not enter into matters pertaining to the correct character of test bar for the making of physical tests of malleable cast iron, but it is necessary for me to point out certain facts that tend towards results that are misleading. Many test bars are made with a reduced section for the double purpose of enabling the grips of the machine to better hold the specimens, and of forcing the bar to break outside the grips. A bar cast in this manner is nearly always defective due to the inability of the iron to set normally. First, the liability of a shrink existing at the fillet, and second, to the fact that the tightly packed sand around the reduced section of the bar acts as a core to prevent the normal setting of the molecular structure in the region of the center of its length.

Where bars are of uniform section throughout, and either round or square, defects are of frequent occurrence at the central portion of the bars. Now, when experiments are made to determine the difference in strength between skin and core, by the time the finishing cut is made at least 1/16-inch of the stock has been removed all around the bar, and this represents perhaps 30 per cent of the original area, and at times more is removed all around the bars, and this skin exceeds this amount in depth. If

the region around the central portion of the test bar is unsound, due to any cause, what chance is there of arriving at correct conclusions as to the relative strength of metal in skin and core?

Another bad practice in the making of such experiments lies in the failure to make the surface of the bar smooth after the final cut. When a bar is machined for test, the surface should be gone over with a Swiss file or very fine emery cloth before the bar is removed from the lathe, failing which I do not believe the results to be trustworthy.

As before stated, the microscope shows no appreciable difference in structural composition in different parts of the core of pieces of good malleable iron, be the bar as large as 2 inches square, and the sole difference between the structural composition of the skin and core is that there is an absence of free carbon in the ferrite of the skin.

If there is any reason why there should exist a great difference in strength between the metal of the skin and core surely there should be seen some tangible evidence under the microscope. When such cases happen in steel or gray iron, the microscope immediately makes manifest the cause, and there is no difficulty whatever in making plain the reason for the alteration in strength, as there will be seen a difference in grain-size between the parts, in structural composition, in unsoundness or oxides. In order to go into this matter along lines that may appeal as being more satisfactory than a mere discussion of the situation, we have made some physical tests conducted under conditions of extreme severity as compared with the regular tensile test.

This was done first, because the greater part of malleable iron castings are subject to dynamic stresses; that is, subjected to great abuse in service; second, in the selection of a test bar where any unsoundness will be restricted to a part of the bar that will not affect the correctness of the results; and third, for a reason that will appear later.

The form of the test bar is a wedge 1 inch wide throughout and 6 inches long; ½-inch thick at the base, and tapering to 1/16 inch at the top. This wedge, when tested under a specially designed test hammer, has its thin end first bent slightly over by hitting it a few slight blows with a hand hammer for the purpose of facilitating the curling up of the bar when it is subsequently placed on the anvil of the test hammer to be struck repeated blows until fracture takes place. In testing the bar, it is held upright on the anvil, when the hammer-weight, delivering a 70-foot pound blow, is allowed to fall on it. If the metal is ductile and strong it will curl up more and more until failure takes place, and the number of blows required to produce fracture and the amount of the curl become a direct measure of the strength and ductility of the metal.

The following are the results of the tests, the weight delivering a blow of 70-foot pounds when the wedge starts to curl, and a slightly greater force after each succeeding blow:

Afternoon heat of June 3.

Unmachined wedges	Machined wedges
Average of 4 tests	Average of 4 tests
18.5 blows	13.2 blows

Afternoon heat of June 4.

Unmachined wedges	Machined wedges
Average of 4 tests	Average of 4 tests
29.75 blows	26.3 blows

Morning heat of June 6.

Unmachined wedges	Machined wedges
Average of 4 tests	Average of 4 tests
19.75 blows	21.2 blows

Here we have one case where the machined wedges actually stood a better test than the ones with the skin on, but setting this aside as unusual, which I believe would prove to be the case, can anyone state after the physitests herewith presented that malleable iron with absolutely all its skin removed is neither ductile nor trustworthy?

In Fig. 3 can be seen four such test wedges that have been struck repeated blows, the blows being stopped the moment it was seen that fracture had commenced. I will refer more specifically to this illustration later as at the present time I simply desire to demonstrate the manner in which they curl up under test.

A pattern was made for a wedge of the above dimensions, and another was made of the same length and width, but ⅝-inch thick at the base and 3/16-inch at the other end. When 1/16-inch of metal is planed off of the two 1 x 6-inch faces of the latter wedge, we have one that corresponds exactly in size with the other, so that through the aid of these two patterns, and the machining of the larger as described, we can secure wedges of the same dimensions, one with the skin on and the other with 1/16-inch of the surface metal removed. We will see later just what the removal of this amount of metal means.

Fig. 3 shows four of these machined wedges that have stood 24, 24, 21 and 20 blows of 70-foot-pounds, respectively. Remember that the heavy blow delivered by this weight is falling on very light sections that vary in size from 1/16 x 1-inch to the largest of 7/16 x 1-inch, at which section they usually fail.

We now come to the third reason for the selection of this type of bar for the test. Calculation will show that after 1/16 inch has been machined from each side of the wedge, about 20 per cent of the stock has been removed from the base; about 66 per cent from the thin end section, and about 26 per cent at the section where failure usually takes place. If this is not testing the core of the metal with a vengeance, I am open to suggestions that may show a better method of procedure, or a fairer one. I also desire to state that these wedges were cast from regular iron as made from day to day, and that they received no treatment other than what the regular run of commercial castings made at this plant are given. I have individual cases of machined wedges that have stood as high as 29 blows. Through the courtesy of a manufacturer of steel castings I had some steel wedges cast from the same pattern as that from which the malleable iron ones were made, and these stood 19, 21 and 23 blows respectively, when tested in exactly the same manner.

Electric Steel Castings Made on a Large Scale

(*Continued from page 6*)

the Central Iron Works, Quincy, Ill., ranging in size from 20 x 42 inch to 36 x 60 inch, together with a rotary automatic type Hoevel sand blast machine, grinders, etc. Compressed air is utilized for chipping. Before being shipped the castings are weighed on a Springfield automatic scale which is installed in the cleaning department. It has a capacity of 10,000 pounds.

The pattern shop which is situated on a mezzanine floor, as indicated in Fig. 10, has an area of 1,243 square feet. It is provided with the customary equipment, including ten patternmakers' benches. The tools are completely equipped with guards for the prevention of accidents. The patterns are stored in a gallery which extends the full length of the shop opposite the electric furnace and cupola. It is fireproof and has a total floor space of over 5,000 square feet.

One end of the pattern gallery is set aside for the equipment used in generating oxygen and acetylene for welding and cutting purposes. This equipment was furnished by the Davis-Bournonville Co., New York. The oxygen is manufactured electrolytically, using a 25-kilowatt motor-generator set.

Special attention has been given to the comfort of the workmen. The building is heated by steam generated in two 72-inch by 18-foot return tubular boilers built by the Springfield Boiler & Mfg. Co., Springfield, Ill.

Fifty Safety Rules for the Operation of Cranes

Necessary Precautions to be Observed by Cranemen Are Outlined to Prevent Accidents in Foundries

A SAFETY bulletin, recently issued by the committee on safety and sanitation of the National Founders' Association is devoted to rules for cranemen. It is stated that the careless craneman, by his carelessness, may thwart the most careful plans of the management for the safety of its employes. Similarly the craneman who is well-meaning, but not thoroughly familiar with the cause and effect of right and wrong applications of the crane mechanism, may blunder into a most disastrous accident. It therefore is imperative that cranemen should be thoroughly impressed with safe ways of handling the cranes under their charge.

Traveling cranes which are operated from a cage attached to the crane bridge are liable to cause more frequent and more serious injuries than other types because the former usually carry heavy loads at considerable speed over great areas of floor upon which employes are engaged in work. Most cage-operated cranes are electrically-driven. The rules suggested, therefore, are especially designed for electrically-driven, cage-operated traveling cranes.

Fifty Crane Rules

Satisfactory crane rules are in effect in many plants, yet they differ in language and in details. A number of these have been gathered and studied while close observation of crane hazards in all kinds of plants has suggested others. Out of this study has grown the 50 crane rules suggested.

Not all of these rules, however, are applicable to every cage-operated, electrically-driven crane in every plant, because of the great variety of such cranes in service and the many different conditions under which they must operate. These rules, if not adopted in their entirety, may nevertheless be used as a foundation upon which a set of rules may be formulated for each plant, to suit local conditions; they may even suggest rules for operation of other types of cranes as well:

1.—Cranes must be operated only by regular crane operators, authorized substitutes, crane repairmen or inspectors; no one else should enter the crane cage.

2.—Access to and exit from the crane cage should always be by stationary ladders, stairways or platforms provided for the purpose. Cranemen must keep their hands free when going up and down ladders.

3.—Articles which are too large to go into the craneman's pockets or belts should be lifted to or lowered from the crane by a hand line kept in the cage for such use.

4.—Cages should be kept free of clothing and other personal belongings. Tools, extra fuses, oil cans, waste and other articles necessary in the crane cage should be stored in a tool box, and not left loose on or about crane.

5.—A pail filled with sand should be carried in the crane cage for use in case of fire.

Rules for Crane Operators

6.—The operator should familiarize himself fully with all crane rules and with the crane mechanism and its proper care. He must not tamper with any mechanical or electrical adjustment, but if adjustments are necessary he should report the same at once to foreman or repairman.

7.—Operator must not eat, smoke or read while on duty nor operate crane when he is in poor physical condition.

8.—Operator must be constantly alert in watching crane and floor operations, and workmen under or near the load.

9.—Operator or some one specially designated by the foreman must daily oil all working parts of crane including sheave blocks, fill empty grease cups, turn down others and make sure that oil passages are not clogged. Hoist chains and cables must be lubricated regularly as directed by foreman.

10.—Operator must examine crane daily for loose parts or defects and report same immediately to foreman or repairman.

11.—Operator must clean crane weekly or oftener as directed.

12.—Operator must test foot brake and limit switch at beginning of each working period.

13.—Operator must avoid, as far as possible, carrying loads over workmen; it must be absolutely avoided when carrying molten metal.

14.—Operator must lift loads only high enough to clear safely all men and obstacles upon the floor.

15.—Whenever loads are to be carried over a long distance to a high position, they should be carried as close to floor as feasible until final location is reached; load should then be lifted to desired height.

16.—Operator must never go or allow any one else to go on crane bridge without first opening main switch; if crane is provided with an emergency switch, that also must be opened. Preferably, switch must be locked open, or warning sign placed and kept upon it, while any person remains on the bridge.

17.—Whenever operator finds main or emergency switch open, he must not close it, even when starting on regular duty, until he has made sure that no one is on or about the bridge or runway.

18.—Before closing main switch, operator must make sure that all controllers are in *off* position.

19.—Operator must move controllers slowly from point to point to gradually increase speed of motors, and must restrict speed until slack in chain or cable has been taken up.

20.—In case of electrical short circuit or if a controller should stick, operator must immediately throw all controllers, except the one that sticks, into *off* position, then open main switch with a rapid motion and notify foreman or repairman.

21.—If power goes off, operator must immediately throw all controllers to *off* position until power is again available.

22.—Operator must not run more than two motors at one time; when handling molten metal it is advisable to run only one motor at a time.

23.—Operator must not reverse a motor until it has come to a full stop, except to avoid accidents.

24.—Operator must pay special attention to the block when long hitches are made, to avoid tripping limit switch or running block upon the drum. When it is necessary to hoist beyond limit switch, operator must first secure foreman's approval.

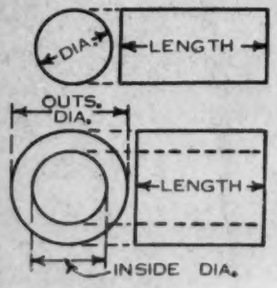
25.—Operator must not lift or suspend a load when there are less than two full wraps of cable or chain upon the drum.

26.—Operator must recognize signals only from the one man who is

WEIGHT OF RODS OR CYLINDERS PER RUNNING INCH

By W. L. Tryon

Below is given the weights of rods or cylinders of different materials, 1 inch long. To find the weight of a cylinder of any length multiply the weight per running inch obtained from the table below by the length.



To find the weight of a tube of any length, subtract the weight per running inch corresponding to the inside diameter from the weight per running inch corresponding to the outside diameter, and then multiply this result by the length. This product is the weight required.

Dia. in inches.	Weight of rod or cylinder 1 inch long when cast in: Cast iron.	Steel.	Aluminum.	Copper.	Zinc.	Gun metal.	Yellow brass.	Dia. in inches.	Cast iron.	Steel.	Aluminum.	Copper.	Zinc.	Gun metal.	Yellow brass.
1/16	.0288	.0313	.0106	.0353	.0279	.0348	.0334	4 1/16	3.48	3.79	1.29	4.27	3.37	4.21	4.04
1/8	.0511	.0556	.0189	.0627	.0496	.0619	.0594	4 1/8	3.69	4.02	1.37	4.53	3.58	4.47	4.29
3/16	.0799	.0869	.0295	.0980	.0775	.0967	.0928	4 3/16	3.91	4.26	1.45	4.80	3.80	4.74	4.55
1/4	.115	.125	.0425	.141	.112	.139	.134	4 1/4	4.14	4.51	1.53	5.08	4.02	5.01	4.81
5/16	.157	.170	.0579	.192	.152	.190	.182	4 5/16	4.37	4.76	1.62	5.37	4.24	5.30	5.08
1	.204	.223	.0756	.251	.198	.248	.238	4 1/4	4.61	5.02	1.71	5.66	4.47	5.59	5.36
1 1/16	.259	.282	.0957	.318	.251	.313	.301	4 7/16	4.86	5.29	1.80	5.96	4.71	5.88	5.65
1 1/8	.320	.348	.118	.392	.310	.387	.371	5	5.11	5.56	1.89	6.27	4.96	6.19	5.94
1 3/16	.387	.421	.143	.474	.375	.468	.449	5 1/16	5.37	5.84	1.99	6.59	5.21	6.50	6.24
1 1/4	.460	.501	.170	.565	.446	.557	.535	5 1/8	5.64	6.13	2.08	6.92	5.47	6.83	6.55
1 5/16	.540	.588	.200	.663	.524	.654	.627	5 3/16	5.91	6.43	2.19	7.25	5.73	7.15	6.86
1 3/8	.626	.681	.232	.769	.607	.758	.728	5 1/4	6.19	6.73	2.29	7.59	6.00	7.49	7.19
1 7/16	.719	.782	.266	.882	.697	.871	.835	5 5/16	6.47	7.04	2.39	7.94	6.27	7.83	7.52
2	.818	.890	.303	1.00	.793	.990	.950	5 3/8	6.76	7.36	2.50	8.30	6.56	8.19	7.85
2 1/16	.924	1.01	.342	1.13	.895	1.11	1.07	5 7/16	7.06	7.68	2.61	8.66	6.84	8.54	8.20
2 1/8	1.04	1.13	.383	1.27	1.00	1.25	1.20	6	7.36	8.01	2.72	9.03	7.14	8.91	8.55
2 3/16	1.15	1.26	.427	1.42	1.12	1.40	1.34	6 1/16	7.67	8.35	2.83	9.41	7.44	9.28	8.91
2 1/4	1.28	1.39	.473	1.57	1.24	1.55	1.48	6 1/8	7.99	8.69	2.95	9.80	7.75	9.67	9.28
2 5/16	1.41	1.54	.521	1.73	1.37	1.71	1.64	6 3/16	8.31	9.04	3.07	10.20	8.06	10.06	9.65
2 3/8	1.55	1.69	.572	1.90	1.50	1.87	1.80	6 1/4	8.64	9.40	3.20	10.60	8.38	10.46	10.04
2 7/16	1.69	1.84	.625	2.07	1.64	2.04	1.96	6 5/16	8.98	9.77	3.32	11.01	8.70	10.86	10.43
3	1.84	2.01	.681	2.26	1.78	2.23	2.14	6 3/8	9.32	10.14	3.45	11.43	9.04	11.28	10.82
3 1/16	2.00	2.18	.739	2.45	1.94	2.42	2.32	6 7/16	9.67	10.52	3.57	11.86	9.37	11.70	11.23
3 1/8	2.16	2.35	.799	2.65	2.09	2.61	2.51	7	10.02	10.90	3.71	12.30	9.72	12.13	11.64
3 3/16	2.33	2.53	.862	2.86	2.26	2.82	2.71	7 1/16	10.38	11.30	3.84	12.74	10.07	12.57	12.06
3 1/4	2.51	2.73	.927	3.07	2.43	3.03	2.91	7 1/8	10.75	11.70	3.98	13.19	10.42	13.01	12.49
3 5/16	2.69	2.92	.994	3.30	2.61	3.25	3.12	7 3/16	11.12	12.10	4.11	13.65	10.79	13.47	12.92
3 3/8	2.88	3.13	1.06	3.53	2.79	3.48	3.34	7 1/4	11.50	12.52	4.25	14.11	11.16	13.92	13.36
3 7/16	3.07	3.34	1.14	3.77	2.97	3.72	3.57	7 5/16	11.89	12.94	4.40	14.59	11.53	14.39	13.81
4	3.27	3.57	1.21	4.01	3.17	3.96	3.80	7 1/4	12.28	13.36	4.54	15.07	11.91	14.87	14.27

WEIGHT OF RODS OR CYLINDERS PER RUNNING INCH

By W. L. Tryon

Dia. in inches.	Weight of rod or cylinder 1 inch long when cast in: Cast iron.	Steel.	Aluminum.	Copper.	Zinc.	Gun metal.	Yellow brass.	Dia. in inches.	Cast iron.	Steel.	Aluminum.	Copper.	Zinc.	Gun metal.	Yellow brass.
7 1/16	12.68	13.80	4.69	15.56	12.30	15.35	14.73	12 1/16	33.25	36.17	12.30	40.79	32.24	40.25	38.62
8	13.09	14.24	4.84	16.06	12.69	15.84	15.20	12 1/8	33.90	36.88	12.54	41.60	32.87	41.04	39.38
8 1/16	13.50	14.69	4.99	16.57	13.09	16.35	15.68	13	34.56	37.60	12.78	42.41	33.51	41.84	40.15
8 1/8	13.92	15.14	5.15	17.08	13.50	16.85	16.17	13 1/16	35.23	38.33	13.03	43.23	34.16	42.65	40.93
8 3/16	14.34	15.61	5.30	17.60	13.91	17.36	16.66	13 1/8	35.91	39.06	13.28	44.05	34.82	43.46	41.71
8 1/4	14.78	16.08	5.47	18.13	14.33	17.89	17.17	13 3/16	36.59	39.80	13.53	44.89	35.48	44.30	42.50
8 5/16	15.21	16.55	5.63	18.67	14.75	18.42	17.67	13 1/4	37.27	40.55	13.78	45.73	36.14	45.12	43.30
8 3/8	15.66	17.04	5.79	19.21	15.18	18.95	18.19	13 5/16	37.97	41.31	14.04	46.58	36.82	45.96	44.10
8 7/16	16.11	17.53	5.96	19.77	15.62	19.50	18.71	13 3/8	38.67	42.07	14.30	47.44	37.49	46.81	44.92
9	16.57	18.02	6.13	20.33	16.06	20.06	19.24	13 7/16	39.37	42.84	14.56	48.31	38.18	47.67	45.74
9 1/16	17.03	18.53	6.30	20.89	16.51	20.61	19.78	14	40.09	43.62	14.82	49.18	38.87	48.53	46.57
9 1/8	17.50	19.04	6.47	21.47	16.97	21.18	20.33	14 1/16	40.80	44.39	15.09	50.07	39.57	49.40	47.40
9 3/16	17.98	19.56	6.65	22.05	17.43	21.76	20.88	14 1/8	41.53	45.18	15.36	50.96	40.27	50.28	48.24
9 1/4	18.46	20.08	6.83	22.65	17.90	22.35	21.44	14 3/16	42.26	45.98	15.63	51.85	40.98	51.16	49.09
9 5/16	18.95	20.61	7.01	23.25	18.37	22.94	22.01	14 1/4	43.00	46.78	15.90	52.76	41.70	52.06	49.95
9 3/8	19.44	21.15	7.19	23.85	18.85	23.53	22.59	14 5/16	43.74	47.59	16.18	53.67	42.42	52.96	50.82
9 7/16	19.94	21.70	7.38	24.47	19.34	24.14	23.17	14 3/8	44.50	48.41	16.46	54.59	43.15	53.86	51.69
10	20.45	22.25	7.56	25.09	19.83	24.77	23.76	14 7/16	45.25	49.23	16.74	55.52	43.88	54.78	52.57
10 1/16	20.97	22.81	7.75	25.72	20.33	25.38	24.36	15	46.02	50.06	17.02	56.46	44.62	55.71	53.46
10 1/8	21.49	23.38	7.95	26.36	20.84	26.01	24.96	15 1/16	47.56	51.75	17.59	58.36	46.12	57.58	55.25
10 3/16	22.01	23.95	8.14	27.01	21.35	26.65	25.57	15 1/8	49.14	53.46	18.17	60.29	47.64	59.49	57.08
10 1/4	22.55	24.53	8.34	27.67	21.86	27.28	26.19	15 3/16	50.73	55.20	18.76	62.25	49.19	61.41	58.94
10 5/16	23.09	25.12	8.54	28.33	22.39	27.94	26.82	16	52.36	56.96	19.36	64.24	50.76	63.37	60.82
10 3/8	23.63	25.71	8.74	29.00	22.92	28.61	27.46	16 1/4	54.01	58.76	19.97	66.26	52.36	65.38	62.74
10 7/16	24.19	26.32	8.95	29.68	23.45	29.28	28.10	16 1/2	55.68	60.58	20.59	68.32	54.00	67.41	64.68
11	24.75	26.92	9.15	30.36	24.00	29.96	28.75	16 3/4	57.38	62.43	21.22	70.40	55.64	69.46	66.66
11 1/16	25.31	27.54	9.36	31.06	24.54	30.64	29.40	17	59.11	64.30	21.86	72.52	57.31	71.55	68.66
11 1/8	25.88	28.16	9.57	31.76	25.09	31.34	30.07	17 1/4	60.86	66.21	22.51	74.67	59.01	73.68	70.70
11 3/16	26.46	28.79	9.79	32.47	25.66	32.04	30.74	17 1/2	62.63	68.14	23.16	76.85	60.73	75.83	72.76
11 1/4	27.05	29.43	10.00	33.19	26.23	32.75	31.42	17 3/4	64.44	70.10	23.83	79.06	62.48	78.01	74.85
11 5/16	27.64	30.07	10.22	33.91	26.80	33.46	32.11	18	66.26	72.09	24.51	81.30	64.25	80.22	76.98
11 3/8	28.24	30.72	10.44	34.64	27.38	34.18	32.80	18 1/4	68.12	74.11	25.19	83.58	65.05	82.47	79.13
11 7/16	28.84	31.38	10.67	35.39	27.97	34.92	33.50	18 1/2	70.00	76.15	25.89	85.88	67.87	84.74	81.31
12	29.45	32.04	10.89	36.13	28.56	35.65	34.21	18 3/4	71.90	78.22	26.59	88.22	69.72	87.05	83.53
12 1/16	30.07	32.71	11.12	36.89	29.16	36.40	34.93	19	73.83	80.32	27.30	90.59	71.59	89.38	85.77
12 1/8	30.69	33.39	11.35	37.66	29.76	37.16	35.65	19 1/4	75.79	82.45	28.03	92.99	73.49	91.75	88.04
12 3/16	31.32	34.08	11.58	38.43	30.37	37.92	36.38	19 1/2	77.77	84.61	28.76	95.42	75.41	94.15	90.34
12 1/4	31.96	34.77	11.82	39.21	30.99	38.69	37.12	19 3/4	79.77	86.79	29.50	97.88	77.36	96.58	92.67
12 5/16	32.60	35.47	12.06	40.00	31.61	39.47	37.87	20	81.81	89.00	30.25	100.4	79.33	99.03	95.03

For finding weights of rods or cylinders of any length see preceding data sheet.

Note—This sheet may be cut into two sections, 5 x 7 inches, and may be readily bound in note-book form.

THE FOUNDRY DATA SHEET, JANUARY, 1915

Payment will be made for all contributions on foundry and pattern shop practice suitable for publication

supervising the lift. Operating signals should follow an approved standard; they should be manual, never verbal. Whistle signals may be used where one crane only is in operation.

27.—Before starting to hoist, operator must place trolley directly over load to avoid swinging it when hoisted. This precaution is especially important when handling molten metal.

28.—Operator must not make side pulls with crane except when especially instructed by foreman.

29.—Except on order of foreman, operator must not lift load when operation of controller shows that load is excessively heavy.

Handling Maximum Loads

30.—When handling maximum loads, particularly ladles of molten metal, operator must test hoist brakes after load has been lifted a few inches; if brakes do not hold, load should be lowered at once and the brakes adjusted or repaired.

31.—If hoist brake refuse to hold while crane is handling molten metal, it may be necessary, in order not to interrupt the pouring operation, to sustain load by short upward movements of hoist, to counteract settling of load.

32.—Bumping into runway stops or other cranes must be avoided. When operator is ordered to engage with or push other cranes, he must do so with special care for safety of persons and cranes.

33.—When two or more cranes are used in combination to lift one load, the several operators must be careful to lift load evenly.

34.—When lowering a load, operator must proceed carefully and make sure that he has load under safe control at all times.

35.—When leaving cage, operator must throw all controllers to *off* position and open main switch.

36.—If crane is located outdoors, operator must also lock crane in secure position to prevent it from being blown off or along the track by severe wind.

37.—In all doubtful cases operator should consult foreman or inspector.

Rules for Floorman

38.—Floorman shall give all signals to the operator in accordance with approved standards.

39.—Floorman shall be responsible for the condition and selection of all hoisting accessories and for all hitches.

40.—Before operator moves crane upon which empty chain slings are hanging, floorman must hook both ends of slings to block.

41.—Floorman, whenever possible, shall walk ahead of moving load and warn people to keep clear of it. He shall see to it that load is carried high enough to clear all obstructions.

42.—Floorman must notify the foreman in advance when an extra heavy load is to be handled.

43.—Floorman should not himself ride or allow others to ride on hook or load except upon authority of foreman.

44.—Repairmen should have crane that is to be repaired run to a location where the repair work will least interfere with other cranes and with operations on floor.

45.—Before starting repairs, repairman must see that all controllers are thrown to off position, that main switch and emergency switch are opened and that, except for short time repairs all fuses are removed.

46.—Repairman should immediately place red flags or out of order signs on crane to be repaired and approved warning signs on floor beneath. Where feasible, space under crane should be roped off. If other cranes are operated on the same runway, he must also place rail stops at a safe distance.

47.—Before removing any part which may release hoist block, repairman must run block to floor, or if this is not possible, he must wedge the gearing to prevent drum from unwinding.

48.—When repairing runways, repairman should place rail stops and red flags at both ends of section to be repaired.

49.—Repairman must take care to prevent loose parts from falling or being thrown upon floor beneath.

50.—Upon completion of repairs, cranemen must remove all blocking and all loose parts, bolts and tools, and put the crane in operating condition. He must then remove rail stops, red flags and warning signs and turn the crane over to operator.

Some Points on Cupola Practice

By R C Hogden

WHEN a new foreman takes charge of a foundry that has been operated for any length of time, he is liable to adopt methods that previously have been tried in the shop, when in reality if that practice were up-to-date, the man before him would have held his position and there would have been no need of making a change in the management of this department.

A foreman may be a good, practical, all-around molder and may be able to make any piece brought into his plant, but in casting this particular piece it is spoiled and goes to the scrap pile on account of his lack of knowledge of correct cupola operations. Molders are blamed for a great many defects in castings that can be traced to the improper management of the cupola.

How many foundry foremen, if asked "What weight of charges does your cupola require for best results"? could tell you? They might give the amount of their charges, but still be as far from the question as before. But if they would take the area of the cupola at the melting zone and charge 1½ pounds of iron for every square inch of area, they would have the amount of iron per charge that the cupola could take care of, using coke in the ratio of 1 to 10. Perhaps a better ratio could be attained after a little experimenting. If the iron should come slow and hot too much coke is being used and the melting zone is too high. In such a case you are using time to pour off that should be used in molding. Reduce the amount of coke gradually until a change is brought about. Do this with care, for iron should be fairly hot when poured to produce good castings, especially when there are parts to be machined.

If, on the contrary, you are using too little coke, the iron will be dull. The air or oxygen forced into the cupola through the tuyeres will have to be consumed by the carbon that is in the coke, forming carbon-dioxide and until this oxygen is transformed by perfect combustion into carbon dioxide, it only serves to chill the iron and the result is dull iron. Also, the second charge will start to melt before the first charge is melted, placing the melting zone too low. The melting zone should be kept 18 to 20 inches above the tuyeres. The velocity of the blast also will raise the point where the melting takes place and all iron below this point that is not melted chills the iron coming from the charge above. What is wanted for general work is fairly hot iron, uniformly melted.

The tuyere area should be equal to not less than one-fourth of the area of the cupola at the melting zone. Also, the combined area of the tuyeres

should equal three times the area of the outlet of the blower. Therefore, the area of the outlet of the blower should equal one-twelfth the area of the cupola. These proportions vary either way to some extent, according to conditions that are to be overcome.

A bridge in the cupola can very seldom be seen distinctly, but the writer remembers one case in which it was easily visible. It happened during the first heat after the cupola had been relined and was caused by irregular charging by incompetent help. After the trouble was discovered, the cupola was stopped-up and retapped, but the quantity and quality of iron run off kept decreasing each tap. This continued until finally the flow of iron became so small that it was useless to continue melting, notwithstanding there were 6 feet of coke, iron and slag in the cupola. The cupola had a slag hole in the back of the shell, but it was not used and had been lined over. Nothing could be done but drop the bottom. This was dropped and only the sand bottom and a small portion of the slag fell out.

The employes were told that there would be no iron melted the next day. After the drop had cooled all the cinder was removed from beneath the cupola. Then a jack was placed in the center to loosen the bridge from the lining, but instead of doing this it only started the cupola off of its foundation. Nothing remained to be done but to go to the charging floor and remove the material through the charging door. When the iron and coke had been taken out to a depth of 5 feet, it was suggested that the jack be removed from underneath and a bar used with a sledge to work a hole through the center and let the accumulation of slag coke and iron drop through to the bottom. In this way the cupola was soon cleared and the lining left in good condition. The bridge was caused by a lack of sufficient fuel between charges to hold the bed up to the proper height. As a result, the iron dropped below the melting zone in front of the tuyeres and the cold blast chilled it. The only iron that was melting was the iron in the next charge above, as it was then in the melting zone.

It really was a good thing that the bottom was dropped promptly, for the iron that was melting was not hot enough to be used and a large percentage of it was being chilled by the blast. It would soon have become a solid mass and could not have been removed without first removing a part of the lining that had been recently put in.

Molding Air Compressors on Jolt-Rammers

A SPECIAL study of the problems involved in molding small gray iron cylinders for street railway air brake compressors has been made by the National Brake & Electric Co., Milwaukee. The machines are of the two-cylinder type, direct-geared to an electric motor and the cylinders are molded *en bloc* together with half of the crank case. The walls of both the cylinders and crank case are made as thin as possible compatible with strength, and this condition, coupled with the irregular shape of the piece, makes it difficult to get sound castings. The walls have an average thickness of ¼ inch. The metal must be dense and close-grained, otherwise the compressed air will leak out through the metal. Each casting is given an extremely rigorous test in which minute air leaks are indicated by the use of a solution of soapy water. Castings with the slightest defect are returned to the foundry as scrap. The cylinders are 4 inches in diameter with a 5-inch stroke and successive improvements in the foundry practice have made it possible to reduce the net weight of the finished casting from 230 to 167 pounds. The overall dimensions of the castings are approximately 28 x 24 x 11 inches. Formerly they were molded by hand in wooden flasks, but this method has been superseded by the use of round cast iron flasks and a jar-ramming machine. A Herman pneumatic machine with a table 5 feet square is employed. The flasks are 34 inches in diameter and the drags are 16 and the copes 6 inches in thickness. A gang of four men is employed on the job; two of them are skilled molders and the other two are laborers or helpers. Fifteen cores are set in each mold and two coremakers and a helper are steadily employed on the job. Seventeen core boxes are necessary. The coremakers always keep a day ahead of the molders. In other words, the cores which are made on Monday are baked Monday night and delivered to the molding floor Tuesday morning.

A wood pattern shown at *P* in Fig. 1 is employed. It is placed on a wood bottom board that rests on the table of the jarring machine. The bottom board is provided with an iron rim on which the flask rests. After the drag is rammed it is removed from the machine, turned over and set down on the floor with a 5-ton Northern, electric-driven wall crane. The cope is barred and is butt-rammed by hand after the jar-ramming operation is finished. In handling each day's work, the men first ram all the drags and set the cores and then ram the copes and close the molds. Each mold is provided with a runner box, as shown in Fig. 1. It is rammed on the jarring machine along with the cope. Two run-

FIG. 1—JAR-RAMMING AIR BRAKE COMPRESSOR MOLDS

ners lead from the pouring basin into the mold, where they terminate in a split gate made in the core. The sides of the drag mold opposite the gates are reinforced with baked, sand slab cores, which prevent the metal from washing away the mold.

The use of the jarring machine has greatly increased the production. At the present time each gang of four men turns out 20 molds per day; previously, by hand, a molder and a helper put up four flasks in a day. The new method has reduced the piece rate from $1.10 to 60 cents, at the same time increasing the wages of the men by approximately 36 per cent. Recently in a lot of 400 castings, only four were defective. This is a rather exceptional record, but on all of the work during the month of November, 1914, the foundry losses were 1.30 per cent and the returns from the machine shop aggregated an additional 2 per cent, making the total loss 3.30 per cent.

Strict attention to the cupola practice is believed to be largely responsible for the low loss record that has been achieved. As suggested previously, the metal must be homogeneous, dense, strong and free from pin holes; at the same time it must be easily machined. To bring about this result, a mixture high in manganese and comparatively low in phosphorus and silicon is employed. The silicon in the finished castings runs about 1.18 per cent, the phosphorus about 0.15 per cent and the manganese about 1.50 per cent. No scrap is used and the mixture contains only northern foundry pig iron. Federal iron made at Chicago has been employed extensively. A melting ratio of about 7½ to 1 is obtained, but no special effort is made to economize on coke since the metal in the ladle must be extremely hot. A bed charge of about one ton of coke is dumped into the 54-inch cupola and the subsequent rounds consist of 3,000 pounds of iron to 300 pounds of coke. Special attention is given to the manner of charging the coke, the aim being to build up the charge in the form of a flat cone, thick at the middle and thin around the edges near the lining. It is believed that this distributes the blast more evenly throughout the cross-section of the cupola. The metal is poured hot and although no pyrometer tests have been made, the temperature is believed to be not far from 2,600 degrees Fahr. The molds are poured with a one-ton crane ladle, which carries sufficient iron for ten flasks.

Would the Castings Have Come Straight?

By W. F. Barrows

An order recently was received for a number of cast iron staves to be used as lagging on steam cylinders. A brass pattern was made for the staves, which were 30 inches long, 4 inches wide, ⅜-inch thick, the thickness having been reduced to 3/16-inch underneath the sunken panels on the convex surface. Test castings were made to check the dimensions of the pattern and the job then was put through the foundry. Owing to the fact that the castings were pickled, about three days elapsed before they reached the machine shop and in the meantime a large number of castings were produced. The machine shop superintendent immediately reported that practically all of the castings were warped in the same direction, and it was concluded that the pattern was wrong.

The pattern was immediately examined and it was found that it was absolutely straight. A conference then was held with the molders, who insisted that the work had been done properly. It gradually dawned on all of the shop executives that in view of the shape of the pattern, it would have to be bent to counteract the warping while cooling. As the explanation seemed plausible, the patternmaker agreed to bend the pattern as instructed, but he could not fully understand how a straight casting would result from a crooked pattern. The patternmaker bent the brass pattern as instructed and sent it to the foundry for verification of the plan decided upon. However, he is still waiting for this proof, as the following morning a new foreman was in charge of the shop. He had been told about the lagging pattern and he returned it to the pattern shop to have it straightened. The patternmaker explained that the pattern had been purposely bent because the castings from the original straight pattern came crooked and it was expected that by bending the pattern this fault would be corrected. The straight pattern then was handed to one of the molders who insisted that probably the warped castings were caused by molding the pattern wrong side up. Little further trouble was experienced from warped castings, yet on the other hand the patternmaker often has wished that the crooked pattern had been tested in the foundry to ascertain whether the castings actually would have come straight.

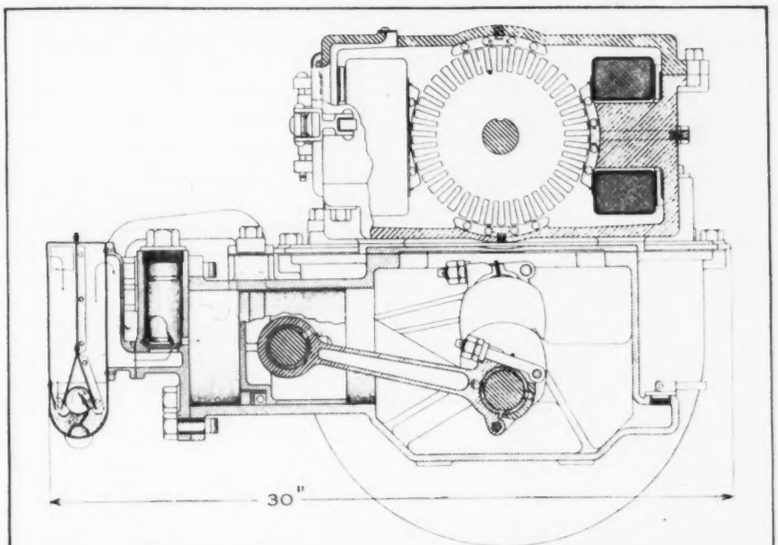


FIG. 2—CROSS-SECTION OF STREET RAILWAY AIR BRAKE COMPRESSOR, SHOWING OUTLINE OF CYLINDER AND CRANK CASE CASTING

Pin Holes and Internal Shrinkage

By W. J. Keep.

Question:—What is the cause of pin holes in the surface of gray iron castings? Recently we made two castings from the same mixture, the cores for both having been skin dried, but the one was made with coarse sand and the other with fine sand. However, the casting from the mold made from the coarse sand is free from pin holes while the surface of the other casting made from fine sand contains a large number of these defects. Can it be possible that the fine sand mixture was the fault? I also would like to know what is the cause of internal shrinkage of gray iron and how it can be overcome.

Answer:—The pin holes should not be formed and an analysis of your castings probably will show that the iron contains more than 0.075 per cent sul-

phur, this high percentage being traceable to your coke and poor quality of scrap. If you cannot remedy this, a small amount of powdered ferro-manganese added to the metal in the ladle will prevent the formation of the pin holes. Also, a small piece of pure aluminum added to the metal in the ladle will bring about the desired results. The sand used permitted the gas formed to affect the iron before it became solid.

Internal shrinkage is caused by the metal remaining fluid in the center of the casting after the surface has become solid. Iron occupies more space when melted than when it is cold. It expands for every degree of heat absorbed by it in the cupola. When the mold is filled a thin skin of solid iron is formed on all surfaces of the mold. This skin becomes thicker as the heat leaves the iron until it is strong enough to hold its shape. The molten iron in this shell keeps on shrinking and the mass naturally becomes smaller. The shell also shrinks, but not so rapidly as the internal mass because of the fact that all of the escaping heat must pass through it. The increase in the thickness of the shell occurs by the formation of small crystals of iron on the inside furnace. There is a very small space between each of the crystals, but so long as the crystals are covered by melted iron there are many points between them making the metal continuous. If the casting is of sufficient size, the crystals will be completed without molten metal around them, in which case they will pull away from their adjacent crystals and sometimes will lie loose without connection with others or they may be connected to other crystals but there is liable to be quite a space between the crystal and its formations. This cannot be prevented, but there are several ways to prevent the casting from being scrapped. The ordinary method is by the use of a riser placed over the highest part of the casting, or to cut a gate in this part of sufficient size to prevent the iron from freezing in it until a firm shell is formed on other parts of the mold. As the molten iron thickens in the riser, hot iron can be fed into it. An iron rod can be used for stirring the iron in the riser to keep the metal fluid. High phosphorus and high silicon cause iron to remain fluid for a longer time than when lower percentages of these elements are contained in the metal. Therefore, silicon is kept as low as possible to insure softness and phosphorus is kept low. However, this content should be sufficient to keep the metal fluid enough to fill the mold. If there is no other practical way of overcoming internal shrinkage, a chill is placed in the mold so as to cause the casting to cool faster at that point than in other sections. Sometimes a piece of iron is anchored in the mold in such a way that it practically becomes a part of the casting.

Slow Melting

By W. J. Keep.

Question:—We operate a 36-inch cupola and to melt 20,000 pounds of iron requires from 3½ to 4 hours. The bed consists of 600 pounds of coke and the succeeding charges contain 1,500 pounds of iron and 150 pounds of coke. Our coke contains carbon, 90.82 per cent; ash, 8.44 per cent and sulphur, 0.64 per cent. The first five tons melt in an hour and 15 to 20 minutes, while the succeeding five tons require from 2 to 2½ hours. After the first five tons are melted the tuyeres freeze and the cupola bridges. We use two shovels full of limestone on each of the last eight charges. Occasionally this helps to eliminate our trouble, but as a rule we experience the difficulty outlined. Our blast pressure is 11 ounces and we have a tuyere area of 3 to 1. The slag drops down to the tuyeres and will not run out of the slag hole, which is opened as soon as five tons have been melted.

Answer:—If your reference to your tuyere area is that it is equal to one-third of the cross section of the cupola, it would practically be a continuous tuyere 3 inches high, which is of sufficient size for your cupola. The other melting conditions are correct. If the furnace is provided with an upper row of tuyeres, these should be closed. Also use limestone of good quality and add it to each charge, tapping the slag as soon as it will run, for example, after two tons of iron have been taken out. The slag never should rise to a point above the tuyeres at any time. You may have a tuyere above the slag hole and if this is the case, it should be closed. However, you might try closing the tuyere with a half brick. Do not under any conditions charge sweepings from the scaffold and break all scrap in as small pieces as the pig iron.

Melting Steel Turnings

Question:—I have contemplated charging heavy steel turnings in the cupola for the purpose of making semi-steel and I have been wondering whether it would be advisable to charge them in the form of cakes. These cakes could be made by packing the borings tightly in a box or snap flask and rusting them together with a weak solution of sal-ammoniac. After the borings are rusted together and the box in the snap flask is removed the briquette is ready to be charged in the cupola. It seems to me that this would make the desired bond and I am wondering whether a very small amount of sal-ammoniac would affect the iron and what the recovery would be.

Answer:—Instead of rusting the turnings, do all you can to prevent this. This, in addition, would be a very expensive procedure and would materially increase your melting losses. A better method of making the briquettes is to bind the turnings with cement, each block containing 50 pounds of turnings. Another method of charging turnings is to pack them in boxes containing approximately 100 pounds and they should be kept in a dry place on the cupola scaffold. The boxes of turnings should be charged as 100 pounds of iron. The box will not be completely burned until it reaches the melting zone and the recovered turnings will approximate 95 per cent. You can melt cast iron borings in the same way and they will improve the quality of your castings. However, be sure to melt the iron hot and do not let the borings get rusty.

To Avoid Chilling

Question:—We are making cast iron fittings and our plugs are slightly chilled on the outside when they are threaded. Our average analysis follows: Silicon, about 3.15 per cent; manganese, 0.67 per cent and sulphur, 0.124 to 0.109 per cent. The iron is rather close-grained.

Answer:—If you can succeed in getting any thread on these castings, you are doing remarkably well in view of the high sulphur content in your iron. By all means reduce the percentage of sulphur.

Core Mixture for Steel Castings

Question:—We are anxious to obtain a good core mixture for small steel castings.

Answer:—The sand is the most important item that enters into core mixtures for steel castings. Owing to the high temperature of molten steel, the core must be made of materials more refractory than used for other metals such as cast iron, etc. Ordinary sharp sands are too fusible for steel castings, silica sand being the only sand that should be used. The purity of the silica also is an important factor and this is indicated by the degree of whiteness of the sand. Silica sand can be bonded the same as any other with any of the various core bonds in use. The core should be made as soft as consistent with handling and should be coated with a wash of silica flour mixed with molasses water to close the pores on the surface and to prevent penetration by the steel and consequent fusion of the core.

Operating a Foundry on a Scientific Basis---III

This Article Gives a Detailed Description of How Time Studies Are Made in Casting Plants

By Frederic A Parkhurst

ALL of the pre-requisites mentioned in the two previous articles have their value as a part of the whole. The actual savings they effect are very great, but we come now to the most radical part of real scientific management, that part which helps us immensely in the development of all the branches of management that have been mentioned earlier in this article and that part which makes possible a larger production than is otherwise obtainable.

Fundamentally we must obtain a thorough knowledge of all factors in a condition to scientifically control it. To do this we must first carefully analyze each thing we have to do into all its elements. Having done this the next step is to take up each branch or element individually and one at a time. The chief element aside from material in foundry work is labor.

The control of methods and the necessary labor element are closely related. In one sense the method is distinct from the labor necessary to make that method effective. On the other hand we cannot dispense with the labor. Our method may contemplate the most complex and efficient mechanical appliance, leaving but little for the human element to do to realize great productiveness from it. Yet, to repeat, we are helpless without the human factor.

In the perfection of methods we bring to bear specially trained minds. The material and tools to be used are carefully determined. The proper combinations of help (if it is gang job) are agreed upon. So too are the sequence of operations and the time each shall take. All of these factors are determined by careful study combined with the use of the stop watch.

To best describe the author's method of making time studies he gives below a modified copy of a set of instructions covering the duties of a time study foreman. This instruction applies to a man in charge of time study work in one of the large foundries in which the author is installing his methods of scientific management. A large amount of detail applying to that particular business has been omitted for obvious reasons. The author hopes that the following will impress the reader with the great importance of this part of the work. Time study work well done is the key to the success of the entire scheme. If improperly or incorrectly carried out it is bound to plunge the entire scheme of organization into chaos. This final outcome can be readily foreseen.

A paper presented at the joint session of the American Foundrymen's Association and the American Institute of Metals, Chicago, Sept. 9, 1914.

The Time Study Foreman

The time study foreman is a member of the planning room force. He is a functional foreman and is directly under the production clerk. Until the new methods are thoroughly operative, however, the time study foreman will be directly under the organizing engineer and will be responsible to him only.

These instructions cover the duties of the time study foreman and his one assistant. They are of course equally applicable in the event that there are more than two men employed on this work. The time study men are immediately responsible to the time study foreman, who will be held strictly responsible for all branches of their work. This also applies to men detailed temporarily from other plants for instruction in time study work.

Too much stress cannot be laid on the importance of the work covered by these instructions. This applies both to the relative importance of this branch of the work to the entire organization as well as to the fact that it is the most important single element of the whole. The success of the entire bonus system is dependent on the reliability of the work of the time study foreman and his assistants, and in the accuracy of their investigations and records.

The observer or time study man should be a skilled man of the trade under investigation. It is not absolutely necessary that he be the fastest worker in the shop, but he must be one of the best. Pride and enthusiasm in his work are two of the chief essentials. To these may be added sound judgment and an unbiased mind, and above all things, he must be patient, exacting and extremely diplomatic. Many opportunities will arise for carrying tales. Care must be taken in conversation with the men that nothing is said which can be misconstrued. These things make trouble and must be absolutely avoided. A man who cannot observe these regulations will not be allowed to have anything to do with time study or bonus work.

The time study men must study the man as well as the job. They must win and retain the confidence of those with whom they come in contact. The time study men are functional foremen in every sense of the word. As such they come in contact sooner or later and more or less often, with every workman in the shop.

The observer when making a time study, should be sure to fill in all the information required at the top of the time study form, as indicated by the printed matter. The substance of the "note" at the top of this form should *always* be borne in mind. Each job must be carefully and thoroughly analyzed into its various elements. The best sequence of operations, as well as the proper tools, feeds, speeds and cuts (if a machine job) must be determined before the study is completed. This is a most important record and must always be complete in itself for later reference.

First of all there are a great many standard elemental times to be determined and tabulated for use in connection with time studies and instruction cards. These elements occur repeatedly on all work of whatever nature which may be done in the different types of machine or by hand. Once determined, they represent a standard to be used in the future for that particular machine or group of like machines or other equipment. In addition to the above, full data must be tabulated covering all details of capacity, power, adaptabilty, etc., of each machine, maximum feeds, cuts, speeds, etc. Other elemental times are also necessary to the expediting and standardizing of this work. For example, standard time allowances for setting different kinds of work in different types of machines, different sizes and styles of clamps and bolts, time needed to raise different weights from floor to machine, both by hand for small parts, and by crane or hoist for larger ones. Different trades, of course, all have different elemental operations.

All of these elemental times represent a much larger proportion of a man's daily work than any one would at first imagine. Although the class of work being done in a shop may vary greatly, both in sizes and shapes, a great deal of a man's time is consumed daily in doing

the same thing over and over again. This statement applies to getting tools, starting and stopping his machine, setting and unsetting tools, making adjustments, performing hand operations, etc. Until an actual record has been made of the time so consumed, and this record compared with the time the same operations should take as proved by stop-watch observations, no one will be convinced of the true state of affairs. The analysis of new work into its elements then becomes a mere matter of applying standard elementary times to most of the elements and calculating or observing the times for the remaining few. Before starting to make a time study, the right workman must be chosen for the job. He must be a fast and conscientious worker and skilled at the kind of work, or branch of the trade, under investigation. If such a man is not available, and a "green" man is to be broken in, the observer must demonstrate the various elements as the study progresses. First of all (other conditions being propitious), the man chosen to do the job must be one who is strictly loyal and thoroughly in sympathy with the new methods. Having chosen such a man, it is generally good practice to pay him 25 per cent of his hourly rate as a bonus for following instructions and while working under the watch. This payment should only apply as long as he continues to conscientiously do the best he can to assist toward an accurate and fair time study of the job in question. After a number of different men have become accustomed to working under the watch, this 25 per cent bonus should be regularly paid to each man when working under these conditions.

It will be somewhat difficult at first to win the operator's good will and hearty co-operation. When it is made clear to him that there are many elements in the job which can be improved, such as a different way of rigging up the job in the first place, or certain combinations of speeds, feeds and cuts, and that he has a chance of earning from 20 per cent to 40 per cent more wages under the new scheme, you have then brought home to him wherein he is to benefit. His work will at once become more interesting; hence, he can do much more work with less fatigue. A man's mental condition and environment are two factors which exert a most far-reaching influence on his output. His own and the employer's interest both require that these two factors be given careful consideration. Under these conditions each man is enabled to stand on his own feet. He is assured of the remuneration that is commensurate with his ability. He will not be wholly subject then to a prevailing rate of wages, which in so many cases is most unjust to both employe and employer. Having chosen the man, the job must be studied and analyzed. This may require much experimenting by trying out one method after another. The tools and fixtures to be used must also be determined and listed so that for future repeat orders the proper tools may be made ready in the tool room and moved to the machine. This should be done in advance of the time the job is scheduled to start. The material must also be on the floor or at the machine or job.

TIME STUDY — Form FAF 111 — THE ALUMINUM CASTINGS CO.

TIME STUDY NO. ..... SHEETS, SHEET .....

ARTICLE ..... PIECE SYMBOL .....

SKETCH OR DRAWING ..... QUANTITY ..... OPERATION .....

MAN NO. ..... MACH. NO. ..... DEPT. ..... WORK, JOB OR ORDER NO. .....

TIME ..... A.M.-P.M.

MATERIAL ..... OBSERVER ..... DATE ..... 19..

NOTE—The observer must exercise extreme care in making time studies to see that the proper sequence of operations is maintained, that all unnecessary operations or moves are eliminated, that proper appliances are provided and if machine work see that the proper and most economical combinations of Speed, Feed and Cut are used. When time is slow, due to man's natural slow moves, note (in margin at extreme right below) what time should be for a fast man moving at his best normal speed. Have certain operations repeated if necessary to satisfy yourself that the time is correct and continue to do so until the study is satisfactory

Sub-Operation	DETAIL DESCRIPTION OF OPERATIONS SPEED, CUTS, ETC	MINUTES AND HUNDREDTHS 1	2	3	AVERAGE	SHOULD TAKE
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
	TOTALS (OR CARRIED FORWARD)					

FINISHED ..... A.M. P.M. ELAPSED TIME FOR ..... = ... MIN

FIG. 6—TIME STUDY FORM

In making a time study, every distinct sub-operation must be timed separately. All time is expressed in minutes and decimals on the time study form, Fig. 6, after which the time is transposed into hours and decimals and figured to the nominal production per nine-hour day. Operation times that are too short to be accurately timed individually may be calculated. This may be done by taking the time for say four sub-operations, then by deducting the time taken for three to get the time for one. As the study progresses, all necessary time should be noted and deducted. This includes time lost due to a man's too slow movements, waiting for or preparing tools, as well as delays from any other source not necessary to the proper performance of the work.

After the work is under way, several time studies from different pieces of the same lot (if there are more than one) should be made on the one form. Three columns are provided for this purpose. In addition the column to the right is to be filled in showing the time that is finally decided on for each sub-operation. Eventually all elemental times will be standard and the times shown for them on the

time study form will be ignored except to account for much waste time. Ten or twelve sheets are often required for one piece, or job, if it be a large or intricate one. The time study when completed will show all the detail times, equal in amount to the total elapsed time. It must be borne in mind that each study is based on a certain design of piece, made of a certain material, using specified equipment and tools, and is not to apply if one or more conditions are changed. The man, however, is the variable factor. The kind and quality of material has also to be taken into consideration. Lack of material or faulty equipment will often prevent a man from earning bonus. The difference in quality of the material is beyond the control of the man, and if it prevents his earning a bonus, the management must expect to make an adjustment. No allowance, however, is to be made for delays in manipulation of the machine, work or tools. A shutdown of the machine for adjustment, cleaning or minor repairs, will not be allowed unless it is shown beyond question that these delays were in no way due to the operator. In some cases, however, the job may be stopped, due to any of the above mentioned delays, and the operator put on other work. When the job is finally resumed, the total time elapsed while it was being worked on is used in determining the time per piece. It is up to the functional foreman to see that the machine and equipment are in proper shape before work is started on any job. It must not be assumed that it is always an easy matter to get a sufficiently accurate time study, and hence a good set of instructions. In point of fact, time studies sometimes have to be made at different times from several successive lots or jobs before a satisfactory instruction card can be issued or a bonus rate set. The time study man must often spend several consecutive days on one job, before he can get a satisfactory study. When this has been obtained, however, it is a comparatively easy matter to write up the instruction cards. These instructions, when written, form the permanent standard for that operation, until a change in one or more of its conditions necessitates a new one. The record in itself looks simple, but the preliminary work involved can be only appreciated by one who has been actively engaged in this kind of work.

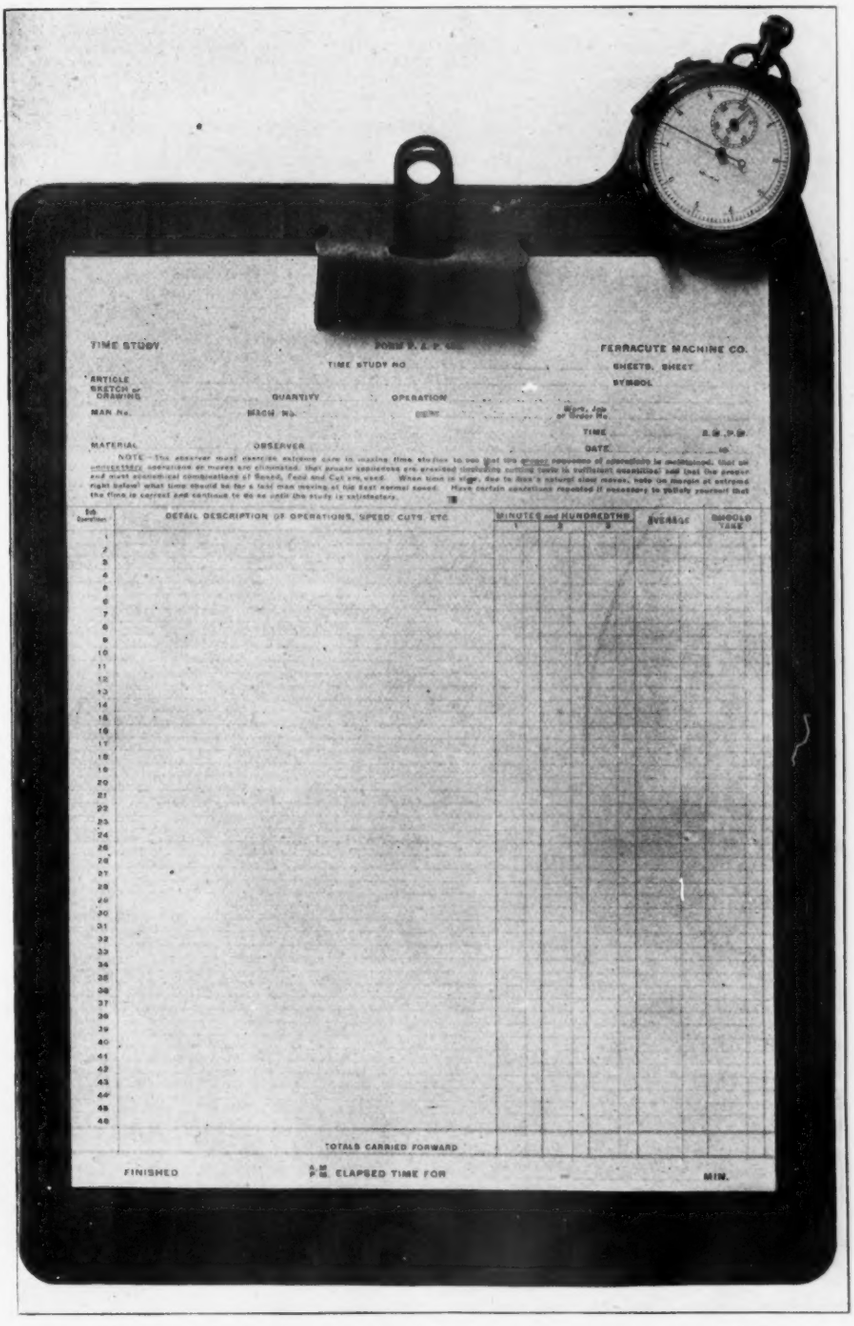


FIG. 7—TIME STUDY OBSERVATION BOARD, WATCH AND FORM

The reader must not be mislead in thinking that after a satisfactory time study has been taken and the instruction card made out, there is nothing more to be done. As often as not, this point marks the beginning of a more or less lengthy period of patient and systematic coaching. In the first place, several different men will probably work on as many successive lots. Until these men have been thoroughly accustomed to bonus work, they will not perform the operation as fast as they can eventually. This is true also of machine operators who perhaps run the same machine from one end of the year to the other, but on many kinds of work. Most men are more adept at one class of work than they are at another, even though it is performed on the same machine. Again, their mental attitude must be considered. They think that although they can earn ten or twelve cents an hour bonus on one job, they can make nothing on some new job. All these conditions and differences of opinion must be met and the employe instructed until he becomes proficient on each job put to him under bonus. This method also results in placing men at the work they are best fitted

Time Study Instructions

Take nothing for granted, get all the *facts* and do not jump at conclusions; let these facts lead you to a conclusion and you will seldom go wrong.

Prepare the heading on the time study form, Fig. 6, filling in *all* the data called for.

Use a decimal stop watch and express all time in minutes or hundredths of a minute, Fig. 7. For each sub-operation make at least three observations. The first of these observations should not be made until the job is rigged up and arranged in the manner in which it is to finally run, until the men have become thoroughly familiar with what is to be done, and until they have obtained a maximum amount of dexterity in the manipulation of the work or tools. The second and third observations should not necessarily follow consecutively after the first. Sometimes it will be of advantage to do this and at other times, it will be better to make the second and third observations at intervals of perhaps several days. The conditions of the job and its nature, as well as other influencing factors will settle this point.

The "average time" (for which a column is provided) is a matter of calculation and can be done after the study is complete. Very often, however, it will be necessary to fill in the time the job should take (for which the extreme right hand column is provided) at the time the three observations are being made. Conditions govern this, but there will be occasions when there is a definite loss of time on a sub-operation due to certain hindrances which can be corrected at the time the observations are being made. If the correct time is not noted immediately, it may be overlooked.

The next step is to see that the equipment which has been provided for the operation is operative and arranged to the best advantage on the floor, bench or other place provided. It is essential that no more floor space be devoted to a job than is necessary for the maximum amount of work; on the other hand, it is equally inefficient, often more so, to provide too little space. In work calling for the co-operation of two or more men, their respective "sub" or "part" based on the time they take, operations should be so arranged that the men can work in unison and with the minimum of delay. Be sure that the tools are in first class condition and in sufficient quantities, and that the man knows how to handle them.

If the best arrangements cannot be determined beforehand, make experiments enough to determine this point beyond question before proceeding further. In such cases, see that your time study form shows an explanation of what this arrangement should be. This may be written in the body of the form in the column headed "detail description of operation, speed, cuts, etc."

Having arranged the above-mentioned preliminaries, the next thing is to carefully study the personnel of the employes. The personal factor is the one great element to be watched, studied, "placed" and controlled before permanent improvement in methods is possible. All these conditions should be taken into consideration as first stated, and the gangs rearranged to suit the job on which they are to be employed. Such changes should be taken up through the planning room and the department foreman. It is fully appreciated that we cannot always make up gangs to suit every individual job. We can, however, regulate our work more or less by classes and divide our gangs into similar classes. Keep each class of workmen as much as possible on the class of work for which they are best fitted.

The next step is to study the details of the job and in a general way separate it into several parts. For example—if it is a "gang" molding job, the work on the cope would be considered one general part of the operation and the work on the drag would be considered another general part of the operation. Other "part operations" would be finishing, core setting, green sand coremaking, closing and clamping molds, setting pouring cups and cups and dumping out. Study each part of the work as though it were a complete "operation" then subdivide it into its sub-operations. In doing this be sure that all unnecessary moves or sub-operations are eliminated. Where more than one man is working on a sub-operation or part operation, see that their respective sub-operations are so timed that they are being done together. In other words, if three men are working on a cope each of them should have something to do all the time that the cope is in their hands; one or two should not be obliged to stand and wait while the one finishes his delayed sub-operation. I have timed many jobs where only two men were involved, and found that they have taken more than twice as long as they should for the reason that the above-mentioned points were utterly ignored.

Take each part of the operation and list on the time study form in the logical and practicable sequence its various sub-operations. Also clearly state under each part the number of men involved and where a sub-operation is done by two or more men be sure to note beside it the number of men. In timing sub-operations be sure to see that an entire combination going to make up the particular operation are working smoothly and that the rough elapsed time is fairly even. Having done this, each sub-operation can be timed independent of all other considerations. Do not lose sight of the fact that the decimal stop watch is arranged to stop and start, accumulating time of each successive operation and need not be thrown back to zero until the sub-operation is completed. If you have started the time on a sub-operation and something interferes with the continuation of it, or causes a delay, stop the watch until the job is resumed at this point and at a normal speed. To illustrate—you may hold the watch on a sub-operation for twenty minutes total elapsed time, but if you follow the above instructions, the watch will sometimes show only perhaps five or six minutes (or less) as the actual required time for that sub-operation.

The manipulation of the watch on the above basis (and judgment of what time to eliminate) is one of the chief essentials when taking time studies. If a time study man cannot master this part of the work and always be sure of the correctness of his time studies, he cannot hold his position. You will find that the average workman often unintentionally combines a great many useless operations. This condition will be found most often where you have laid out a method of operation different from that to which he has been accustomed. Under such circumstances you must expect him to make mistakes and do things in their improper order or do unnecessary things. These should be eliminated. In other words, if the above instructions have been followed out, you have determined a definite method and sequence of operations and *you are only expected to take the time of these necessary operations.* These are the times which are to appear in the columns marked "1", "2" and "3" on the time study form.

In making time studies or observations on other than standard elemental operations, it is not necessary to take the time of any standard elemental sub-operation involved on that particular job. As explained below, all the standard elemental operations will be charted and standard times determined for them. These standard elemental operations will be numbered numerically. Where they form sub-operations as explained above, they may simply be referred to on the time study form by number. When you come to figure up the right hand column to show the time the job should take, the standard elemental time should be taken from the standard elemental time sheets. You will find that eventually the actual time study work involved will be very small, and then only for exceptional work. The time for the majority of operations can be taken from the standard elemental time sheets.

Under no circumstances base a time study on the speed of an unusually fast man; the same thing applies to the unusually slow man, as in either case the result of your time study would be of no value. It must be clearly borne in mind that what we want is the correct time that the job should take when done by the average fast, industrious workman of the type and qualifications necessary for that particular kind of work. Do not be afraid to take averages and the more time you take as a check the better. Furthermore, bear in mind that what time you are taking is to be used as a basis for issuing bonus charts, the prices on which are under no circumstances to be lowered as long as the job remains the same or is done by the same tools, equipment, methods, etc., as were in use when the bonus chart was figured. *It is one of the fundamental principles of scientific management that the facts be correctly determined in the first place and that a schedule in prices or bonus chart is to remain unaltered.* The success of the entire scheme hinges upon this one thing. You must solicit the co-operation of the men, and win and hold their confidence. Super-judgment is necessary; be sure you are right and take time enough to do your work well.

Having completed the time study with at least three sets of final observations, the average time should be figured out for each sub-operation and filled in on the sheet. Sub-operation times should be totalled for each part of the general operation and these "part operations" compared. Then fill in the time that the work should take, doing this by part operations so that the various part operation times may be compared. This really is the time that you have got to work on. Where it is shown that one part of an operation takes longer than another part and that these parts must be completed in substantially the same time, it is obvious that something must be done to balance up the time on the slow part. You know that theoretically the fast operation represents the best normal production for the job. An extra man must be put on the slow operation or some other change made to balance it up with the fast one. When making such a change, it is well to make an additional time study as a check on your figures before issuing instruction cards or bonus charts to the workmen.

On some jobs, operations, or particular classes of work there will be a number of sub-operations which are incident only to the entire job as a whole. For example—when a new job is started there may be instructions to explain, there may be drawings to become familiar with, there may be certain arrangement of the work on the floor, or in the machine which, having once been done, apply to the entire quantity or until the job is completed. Such elements in some cases may be standard elemental operations or they may be special to that job. In any event they are, what we call *lot operations* and the times for them are known as *lot times.* In cases where these lot operations are repeated daily, a proportion of their total should be allotted to the operation under investigation based on, we will say, one day's work. A day's work constitutes a certain given production. The lot time distributable to a day's work should be divided by this number of pieces based on the time study and an item included on the time study to represent the lot time.

In studying operations as above described, be sure that the necessary work at the beginning of the day or at the close of the day's work is included in your time study. Such work is essentially a lot operation, the time for which is "lot time." The care which tools should be given at night and the order in which the floor, bench, machine or job must be left should be clearly settled and the allowance of time for putting it in such condition provided. Such times are primarily daily lot times and are easily distributable pro rata to each operation performed for the day's work. In specifying the condition of equipment be sure that tools which are liable to rust are kept clean and well oiled and also see that the mechanical equipment provided is kept well oiled and adjusted, either by the operators themselves or by the maintenance department. Report all cases of abuse of tools. Do not let men use a shovel for an axe or as a crowbar.

for. They cannot continue to work indifferently for perhaps years when they should have been on other jobs or working at some other trade. The writer has in mind a number of jobs which took from six to fourteen months of unremitting, patient labor on his part before a cent of bonus was earned on them.

If one or more men do not begin to immediately earn bonus after a bonus price has been set, the circumstances must be taken into consideration. They must be given an opportunity to appreciate the fact that the job contains elements which they were before unfamiliar with. Make them realize that they have been shown how they can do the work quickly if they are so inclined. I quote an example which came up in our core room the other day, which is a particularly good illustration of this point. I refer to a half housing core for a transmission. This job had been run under day work from 75 to 85 cores a day and in the judgment of the foreman 90 cores could be made in nine hours. A time study on this job was made personally by the writer and afterwards a more systematic study was made by the time study foreman. The result was that the job figured 0.83 minute per core. Making an allowance of about 10 per cent, the maximum bonus production was figured on a basis of 0.9 minute per core. This means a production of 600 cores per day for one man at the bench. Bonus was started at 70 per cent of this production (420) and the chart above referred to was issued on this basis.

A Core Room Problem

It is a pretty radical proposition to take a "75 to 90 a day" job based on the best judgment of the man in charge of that department and attempt to jump it to 420 before the man can earn any extra remuneration. The man who had been working on this job refused to work under bonus and walked out. A strange man was put on the job and for the first day's work made 460 cores. On the second day he made 537. The foreman in this department then admitted that he believed a man could make 600 of these cores in nine hours. The job after a few days ran from 550 to 600 per day. This example is recorded here as a good illustration of the apparent radicalism of some of the results desired under new methods.

Be perfectly sure of your facts, then instruct and assist the men in every way in realizing the results you aim for. Keep an accurate record of the time you consume while making each time study and if the men are co-operating with you and trying in every way to assist you in making this study, see that a bonus pay slip is turned in for an amount equal to 25 per cent of their wages for the time they were working under the stop watch. Be perfectly open and frank with them while taking time studies and do not get the habit of letting them think you are taking time studies secretly. I am not referring now to making the general superficial study of the job and taking the elapsed time, keeping the watch in the pocket. This method is allowable under certain circumstances as long as it is done discreetly and just as a rough check on conditions. There are only a few cases where such a method is necessary and the writer knows of none where it is desirable.

When taking time studies or arranging the order of work and teaching the men how to perform such work, be sure to make them realize the advantage of working at a steady gait. Do not let the men continue the habit which a great majority of them have, in other words, trying to put up a large proportion of the day's work during the morning period. We have been able to get our men away from this habit and it will be noticed that on practically every bonus job now running an average gait is maintained throughout the day. If the jobs were checked over at noon, you would find that almost invariably there is 5/9 of a day's work completed at 11:30. Such a condition is a most desirable one; the men can do more work with less fatigue than in any other way. For general information, it may be mentioned here that there is a certain limit to which a man can go before becoming unduly fatigued. If a very short rest period is taken at this time a matter of only a few moments even, it will recuperate a man so that he can resume his maximum speed. Let him work a little longer, however, at his maximum speed and it will not require a proportionately increased period of rest to recuperate, but the period will have to be many times longer. A slower average gait steadily maintained as above stated requires a great deal less effort for a greater production.

As each job is taken up and investigated preparatory to making a time study, be sure to get an accurate record of how the job is run, the number of men, and their rates. Also get an accurate record of the production per day both in gross work and net amount of good castings, cores, or whatever unit applies to the job. This information is very essential for comparative purposes as well as to check out your cost after you determine the new way of arranging the job combined with the anticipated production. Very often it is necessary to change a method and at other times it is a very undesirable thing to do.

After you plan the arrangement of a job on the floor or bench, be sure to see that you provide a sufficient quantity of material. No matter how willing the men they cannot work to advantage (nor can you get a satisfactory study) if the flow of material is not sufficient to keep the gang well supplied and far enough ahead so that they do not see the possibility of a tie-up. You must not forget that the average workman is very clever at gaging his speed to suit conditions. Do not under any circumstances think that the men you are dealing with are fools, especially if they are of a different nationality and do not understand English. You will find that the minds of such men are peculiarly active. They are very quick to see an opportunity and to take advantage of it. They are also exceedingly sensitive, far more so than the average better educated person.

Restrict each job, whether it is one-man job or a gang job, to a certain but sufficient amount of floor, rack and bench space. Be careful to make your arrangement of work such that the different material and equipment is handy and can be reached and manipulated without an undue amount of travel or useless motions; on the other hand, allow sufficient room to work to advantage.

Large Gangs Should be Avoided

It is a mistake (except perhaps in isolated cases) to work more than two to six men and boys in a gang on bonus. The individuality of each man is lost and no one in the gang can work to the best advantage for several reasons; chiefly because men vary in capacity. When in too large a gang all are not congenial, are apt to be more or less jealous and antagonistic, or feel that each one is not doing his share and hence holding the others back. Work which can be done by a large gang must be so divided into sections that each section can be handled as a unit by one or two men. The result is the equivalent of a number of small individual units or jobs which at a certain stage of completion, are themselves assembled in a short time, and perhaps by a number of men, into the completed work. In a case of this kind each unit or section is inspected separately as its assembling progresses. The final inspection takes place after the work is complete.

In the capacity of a time study man

be careful to avoid any suggestion of usurping the authority of the foremen or gang bosses. They fully understand the relation of your work to their own; at the same time when you are ordered to take a time study of a job, arrange with the foreman and let him formally turn the men over to you. Very often the foreman will have good reasons for wanting to postpone the starting of such an investigation. These reasons may be due to promises that he has made in regard to his work, or to the fact that there is some change in equipment being made, etc. Such factors should be considered, but in every case report back to your superior. He may have more important reasons for wanting the study to start at once than those which have been given you for delaying it. Where you have occasion to criticize or suggest improvements in methods generally on jobs which you are not personally handling, take such matters up with the foreman or other proper authority. Do not give men instructions unless it is on a job which has been standardized. In such cases it is up to the time study foreman and his assistants to maintain these jobs in their standard condition.

All observations in the form of time studies, either rough superficial investigations or detailed stop watch observations are to be recorded on the time study form, Fig. 6. These forms are to be numbered in consecutive numerical order, commencing at 1. Particular care must be exercised when starting a study on any piece of work to be sure that all of the information called for by the printed matter at the top of this form is filled in. When more than one sheet is used in recording the time study, these sheets must be numbered and the total number of sheets and "sheet number" filled in on each sheet belonging to a set of time studies.

As a general word regarding time studies, the note printed near the top of the time study form should have particular attention, namely—

"The observer must exercise extreme care in making time studies to see that the proper sequence of operations is maintained, that all unnecessary operations or moves are eliminated, that proper appliances are provided and if machine work, see that the proper and most economical combinations of speed, feed and cut are used. When time is slow, due to man's natural slow moves, note (in margin at extreme right below) what the time should be for a fast man moving at his best normal speed. Have certain operations repeated if necessary to satisfy yourself that the time is correct and continue to do so until the study is satisfactory."

The note is printed on the form so that it may always be a continual brief reminder of the several very important elements to be considered in connection with time study work. These are elaborated on in considerable detail below but too much emphasis cannot be laid on their importance. Each time study or observation, whether one of a series of studies of standard elemental sub-operations, or a time study of some specific operation or job, should always be conducted in a systematic and routine manner and in strict accordance with the instructions which accompany this article.

Use of Relief Valves on Cupola Blast Pipes

By a Practical Foundryman

WITHOUT entering too deeply into the chemistry of the matter it may be stated that it takes 150 cubic feet of air for the proper combustion of one pound of coke which will melt ten pounds of iron or 30,000 cubic feet of air will melt one ton of iron an hour in the larger sized cupolas.

Natural draft is out of the question in handling such large volumes of air in so short a time so it must be forced into the cupola by power. Four kinds of apparatus are used for this purpose, the fan blower, the centrifugal blower, the piston type of compressor and the positive pressure blower. The first is used successfully on small stacks where it is not necessary to meet very high pressures. The centrifugal blower is a modified type of this machine which runs at a very high speed, but if the pressure proves too high, the blades wade through the air without positive effect. The reciprocating piston compressor is practically never used in cupola work. The positive pressure blower, however, is frequently employed. Each revolution of such a blower carries a certain amount of air from the suction pipe into the delivery pipe. When there is no resistance, it shows no pressure, but in cupola work it may properly show any pressure from 8 to 26 ounces or more, depending on the size of the cupola, the friction in the piping, the area of the tuyere openings, the amount that the tuyeres become closed by molten iron, slag or coke, and the resistance met by the air making its way up through the iron and coke charges.

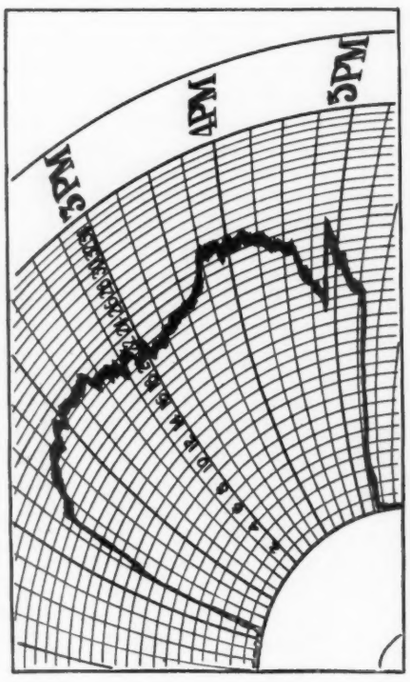


FIG. 1.—RECORD OF BLAST PRESSURE DURING A NORMAL HEAT

This type of blower connected to a cupola and running at a constant number of revolutions per minute will deliver a constant volume free of air.

It is at this point that all the confusion arises for the volume of air is in no way shown by the pressure gage. By enlarging the tuyere openings we could make a blower much too large for the cupola show only eight ounces pressure or by making them too small we could make an undersized blower show over 30 ounces. The pressure gage indicates only the resistance against which the blower is working and not the amount or weight of air that is being forced into the cupola.

Volume is the Important Consideration

Pressure is necessary and it must not be too low, for if it is the air will not reach the coke in the center of the stack; too high pressure on the other hand will cut out the lining.

The tuyeres should be proportioned to the size of the cupola so the pressure will be right, but the volume of air is the first consideration. It is a mistaken idea that the pressure

should be kept below 20 ounces. Many blast systems are fitted with relief valves which open when the pressure reaches that point, just at the time when the cupola needs the full volume of air, for all stacks melt highest at about the middle of the heat.

A study of Fig. 1 makes these points clear. This chart was taken from a cupola lined to 76 inches inside. During four hours' run it melted 97.6 tons or 24.4 tons an hour, but it must have melted considerably more during the middle of the heat to make up for the slow melting at the start and finish. The ratio of iron melted to coke burned was 10.35 to 1. The mixture was as follows: Silicon, 2.62; phosphorus, 0.735; sulphur, 0.039; and manganese 0.571. The castings analysed as follows: Silicon, 2.45; phosphorus 0.380; sulphur, 0.064 and manganese, 0.507. The tuyere area was about 12 per cent of the cupola area. This furnace was melting nearly up to its capacity and made first class iron for light and medium weight high grade castings.

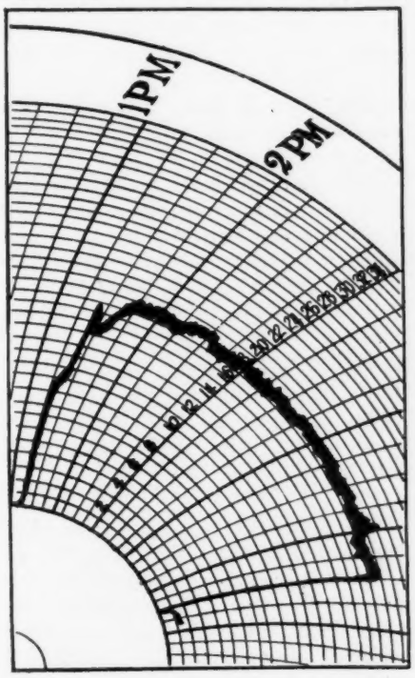


FIG. 2.—RECORD OF BLAST PRESSURE WITH RELIEF VALVE SET AT 18 OUNCES

The wind was put on at 1:15 P. M., the upper tuyeres were opened at 1.20 P. M.; the back pressure built up to 23 ounces by 2:30 P. M., dropping back to 21 ounces which it practically held until 3:15 P. M. when it began to rise until the peak, 25½ ounces, was reached at 3:45 P. M. This was held until 4:15 P. M. when the last charge was put on and immediately the pressure began to drop owing to the reduction in the thickness of the coke and iron charges above the tuyeres. At 4:54 P. M. the upper tuyeres were closed and the pressure went up to 24 ounces only to drop to 17 ounces when the blower was stopped at 5:17 P. M. The bottom was dropped at 5:18 P. M.

Effect of a Relief Valve

The record shown in Fig 2 was made under the same conditions only the system was fitted with a relief valve which automatically opened at 18 ounces. In 4¼ hours 90.52 tons of iron were melted, or at the rate of 21.3 tons per hour. The iron ran sluggishly. The ratio of iron melted to coke burned was 10.22 to 1. The mixture was as follows: Silicon, 2.59; phosphorus, 0.785; sulphur 0.046; and manganese, 0.548. The castings analysed as follows: Silicon, 2.44; phosphorus, 0.804; sulphur, 0.081 and manganese, 0.461.

The wind was put on at 1:15 P. M. and the upper tuyeres were opened at 1:24 P. M., shown by short drop in pressure, which rose immediately to 18 ounces when the automatic relief valve opened and held, letting a considerable volume of air go by until 5:00 P. M. when the closing of the upper tuyeres momentarily raised the pressure. At 5:30 P. M. the blower was stopped and the bottom dropped. The pressure blower furnishing the blast for these tests ran 190 revolutions per minute and displaced 60 cubic feet of air per revolution or 684,000 cubic feet an hour. The result of using a relief valve is easily seen in the lowering of the melting efficiency of the cupola by 12 7-10 per cent., which makes it necessary to put the wind on earlier or to make the men wait longer to pour off. Also there was a larger per cent sulphur in the product.

There is every reason why a cupola should, if possible, melt its full tonnage per hour, for slow melting means that the iron is so much longer in contact with the coke and thus picks up more sulphur. This is shown particularly in Fig. 3, when the cupola was working under the same conditions as outlined above, except that the relief valve opened at 16 ounces. The ratio of iron melted to coke burned was 9.34 to 1, and 18.76 tons were melted per hour.

The first iron was good but the middle and last portions were poor, considerable work not running. The mixture analysed as follows: Silicon, 2.70; phosphorus, 0.815; sulphur, 0.032 and manganese, 0.415. The castings analysed as follows: Silicon, 2.58; phosphorus, 0.800; sulphur, 0.060 and manganese 0.351. Charges of 8,000 pounds of iron were used in these tests. Experiments on half charges showed slower melting and also increased sulphur in the product.

Slow melting generally means dull iron and if there is anything the foundryman should furnish his men, it is good sharp iron for in such cases bad work can only be laid to poor molding. Also a shop having a reputation for good iron has the pick of molders, other conditions being equal.

If the right volume of air is forced into a cupola through proper sized tuyeres and the iron is oxidized, it is because the bed is at the wrong height or the coke and iron charges are of improper weight and is not due to pressure being too high. The pressure gage misleads more than it helps and could practically be dispensed with.

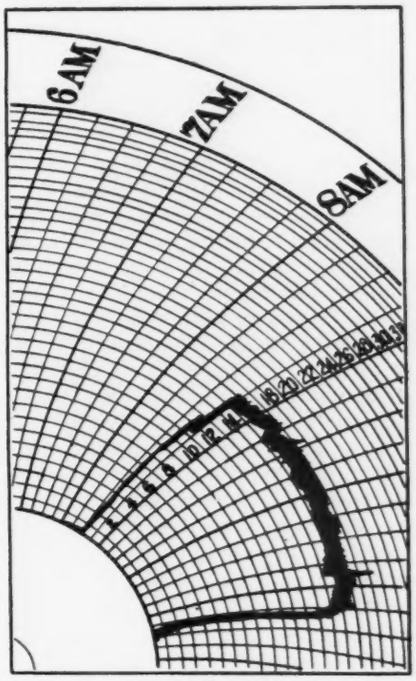


FIG. 3.—BLAST PRESSURE WITH RELIEF VALVE SET AT 16 OUNCES

A relief valve spoils the efficiency of a pressure blower, making it no better than a cheaper fan blower and if used at all should be set to open at a pressure considerably higher than the ordinary working pressure. There is as much reason in placing a relief valve in a cupola blast system, set so that it will open at low pressure, as there would be in placing a check valve in the air supply pipe to the carbureter on an automobile so arranged that it would shut off the air when a grade called for more power, for these are both cases of furnishing the proper volume of air for combustion.

Regulating the Height of Fuel Bed in Cupolas

The Importance of Maintaining Bed at Proper Height to Secure Maximum Temperatures in Melting Zone

By Richard Moldenke

A REQUEST has been made for a table showing weight or height of fuel bed in cupolas of different diameters. This is interesting as it strikes one of the fundamentals of rational cupola melting practice.

Strange as it may seem, the weight of the fuel bed has nothing whatever to do with proper charging, though the height has. It is not the quantity of fuel that counts in the bed, but the distance upward that the blast has to travel before meeting the first charge of metal. In other words, accordingly as the blast volume delivered by fan or blower is regulated, will the oxygen delivered be used up by the fuel at a high or low point, irrespective of the weight of the fuel charge. Naturally, the condition of the fuel will have something to do with quick or slow burning of the carbon. The greater the cellular structure of the coke used the quicker the reactions, and the greater the difficulty of keeping the intermediate coke charges from catching fire too early. There is just one place where practically all the oxygen of the blast will be used up to make carbonic acid (the complete combustion of carbon), and above which—if the bed is too high—there will be another reaction, giving carbon monoxide, which reduces the temperature of the gases, producing an incomplete combustion and wasting fuel. At the above mentioned place will be found conditions of maximum temperature, freedom from oxidizing influences, or ideal conditions for melting. Here should be found the first charge of iron, and as the bed burns away in melting it—replacement being made by the first intermediate fuel charge—the second charge of metal, and so on, all charges being of the same weight.

With ordinary conditions of blast volume delivered to the cupola—meaning in effect a normal melting rate for the given internal cupola diameter—this place of maximum temperature and ideal melting conditions is about 24 inches above the top of the tuyeres (actually 22 to 30 inches, depending upon slow or fast operation of the cupola). The practical test is the time between *blast on* and *first iron*, meaning thereby from the time the wind is put on until the iron runs from the spout sufficiently strong to require closing the tap hole.

A little thought given to this matter shows how delicate and intensely rapid these reactions go on. As the air is forced through the tuyeres, it comes into contact with the fuel, surface combustion takes place, more of the oxygen touches the fuel further up with consequent surface combustion, and so on until all the oxygen has been used. Under normal conditions all this will have happened within the space of one-fortieth of a second. Hence the prime importance of having the bed exactly right in height—not weight. If, therefore, the lining of the cupola has been heavily cut out and only the same weight of fuel is charged, the bed must be too low, and much unconsumed oxygen will touch the melting metal, which will be colder than it should be. Hence the importance of always having the same height of fuel bed for the same blast conditions. The faster the air is blown in, the higher this point, and vice versa.

It therefore, is impossible, and incorrect, to give any table for height of fuel bed in different sized cupolas. Under normal conditions of running all kinds and sizes of cupolas, the height of the bed will be nearly the same—namely that which will give the *first iron* eight to ten minutes after *blast on*.

It should be stated, that once the height of the bed has been fixed, the subsequent fuel charges are entirely regulated by weight. These intermediate charges are intended to replace that portion of the fuel bed burned up in melting the charge of metal below. Here it is a case of burning so much carbon to produce sufficient heat to melt so much iron (usually 1 to 10). Experience has shown that the weight of an intermediate charge of fuel, four inches in thickness, gives the best results. Hence we have here the proper weight for the intermediate coke charge. Ten times more or less, this amount gives the proper metal charge. This holds true for every cupola, in the light of our recent studies on the subject. Hence, also, the fallacy of a big first charge of metal. Were it not for the extra high fuel beds used in cupolas with big first charges, trouble would be in order. There is a natural tendency to pile on a heavy charge of metal on what seems a big lot of coke for the bed. Remembering, however, that only the last four inches of this coke bed does the actual work of melting the metal, and all the rest below is merely preparatory in its usefulness, the requirement of a first metal charge only big enough to use up this four inches of fuel is manifest. If more is taken, the bed is lowered more than can be made up by the first intermediate coke charge.

The rational way of running the cupola is to start with a bed of the proper height and to keep up this height all through the melting. Hence, if proper slagging is resorted to, and the lining does not give out, it is possible to run a cupola continuously day and night. The least deviation from the above program, however, resulting in a change of position of the melting point, especially if downward, means trouble.

Foaming Slag

By W. J. Keep

Question:—We experience great difficulty from foaming slag when we use a mixture containing silicon, 1.68 per cent; manganese, 0.43 per cent; combined carbon, 0.68 per cent and phosphorus, 1.18 per cent. The slag contains 30.96 per cent of iron, 0.87 per cent of manganese and 0.264 per cent phosphorus. Our charge also carries 10 per cent steel. When the silicon in our mixture is above 2 per cent and the phosphorus less than 1 per cent, we experience no difficulty from foaming slag. Our cupola is lined to 30 inches.

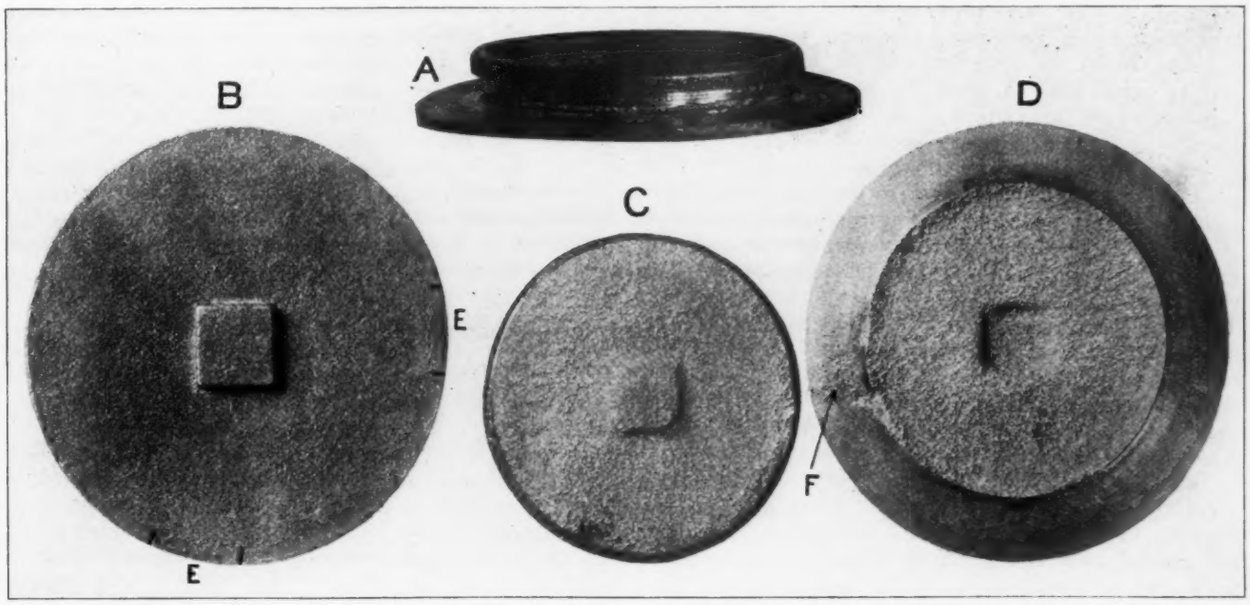
Answer:—Be sure that you charge no large pieces of iron in so small a cupola. The blast pressure should not exceed six or seven ounces and you should provide plenty of tuyere area. You will find that probably the steel scrap and perhaps some of the cast iron is oxidized. The slag should be tapped as fast as it is formed. Also be sure that you are using sufficient fuel. A melting ratio of 6:1 in a cupola of this size must be considered good melting practice. Also, avoid charging dirt into the cupola, particularly the sweepings from the charging platform.

PROBLEMS OF THE BRASS FOUNDER

What To Do and How To Do It

Difficulties With Yellow Brass Trap Covers

We are casting a large number of brass trap covers, as shown in the accompanying illustration, and we have experienced considerable difficulty in their manufacture. The mixture consists of clean, heavy, yellow casting scrap, but notwithstanding the fact that we have tried to mold them flat with different sides up, the same results have been experienced. We would be pleased to have you give us some information as to the cause of this difficulty. The gating of the casting is indicated at E. We would like to have a cheap mixture for this class of work which will produce satisfactory castings. The covers are machined all over and then are nickel-plated.



DEFECTIVE YELLOW BRASS TRAP CASTING WHICH SPLIT AS SHOWN AT *C* AND *D;* THE SIDE VIEW *A*, SHOWS THE DEFECT AT THE JUNCTURE OF THE CUPPED SECTION AND THE FLANGE; THE LOCATION OF THE GATES ARE INDICATED AT *E* IN THE TOP VIEW OF THE TRAP, *B*

Although trap covers are comparatively simple castings, manufacturers of plumbers' supplies frequently experience considerable difficulty in their manufacture. The trouble experienced in this instance is chiefly one of shrinkage and the splitting noted is due to a shortage of metal at the moment when the casting solidifies. It is well known that metal contracts as it passes from the molten to the solid state, yet notwithstanding this, both gated and carded patterns frequently are made with no provision to supply the solidifying casting with liquid metal to compensate for the reduction in the metal mass caused by contraction. In fact, the opposite result frequently is effected and the casting feeds the gate in place of the gate feeding the casting. Thus a solid gate results, but the casting will contain defects which, while remaining hidden, will show externally in a number of instances and will make the loss run high.

The casting, split in halves, is shown at *C* and *D*. The splitting tendency could not be detected until the casting was machined at the juncture of the ring and flange, because the outside of the casting is chilled by the cold sand of the mold. Therefore, at this point the majority of the castings will have a thin, unbroken skin of metal which hides completely the internal defect. The cause of this trouble can be explained easily. The thin flange across which the metal must flow to fill the heavier ring section sets first and, therefore, no metal can pass across from the gates to fill voids in the center of the casting. The defect in the flange at *F*, proves this, as it shows that the metal has been drawn away at this point as much as its fluidity permitted, to feed the contracting center. If the casting were heavier in section, it would shrink in the cope, leaving a depression instead of splitting, as was the case in this instance. The reason for this is that the internal heat of the mass of metal would prevent the formation of a solid skin of metal next to the sand of the mold, of sufficient thickness to bridge the depression formed by contraction. Therefore the skin sinks with the metal underneath.

A casting always will split when the chilled surfaces are held tightly in the position in which they are cast, if the section is comparatively thin and no external supply of molten metal is available to make good the shrinkage. This happens in the case of these trap covers. They are thin in section and the metal is divided fairly uniformly by the sand in the cope and the drag. When forming, the crystals and metallic particles attach themselves to one side or the other until all of the available metal is used and a crack occurs in the center. The two halves are held together with the thin ring of sand-congealed metal at the circumference of the cupped section. That the split occurs whichever way the casting is molded is due to the shape of the section. When molded flange up, this sec-

tion is held in the sand by the overlapping portion of the flange. The cupped section also is held by the sand packed in the center and around the ring and a similar condition prevails when the flange is molded in the drag of the flask, as the cup being light, is held easily by the sand of the cope in this instance. The chances for obtaining sound castings when the flange is cast down are slightly better than when cast up, as there is more of a possibility of the cup settling than the flange, and if this occurs, the two halves will come together and unite when the center is molten and a sound casting will result.

The reason that all of the castings are not defective, regardless of the way in which they are molded, may be traced to the fact that some of them receive sufficient metal through the gates to make good the shrinkage at their centers, the temperature of the metal when poured, the degree of inclination of the flask and the position of the casting with reference to the sprue. All of these factors have their influence upon the splitting phenomenon, so that in some molds no defective castings may be found, while in others the castings nearest to or farthest from the sprue may be split. In any event, it depends entirely upon how the gate and the castings at the highest point of the mold may be able to feed the castings at a lower level. In seeking a remedy it should be remembered that the difficulty essentially is one of shrinkage. Therefore, no chances should be taken in providing a gate of sufficient size to supply plenty of the metal to feed all of the casting. We would suggest that the runner be made heavier in the cope than in the drag of the mold, that the gates connecting the casting and the runner be made as heavy as the runner itself up to the point of juncture with the casting and tapering back from the casting in a manner similar to the gates on malleable castings. One gate, somewhat wider than the gates now used, will be better than two. A heavy gate in conjunction with a heavy runner will prevent the adjacent thin section of metal in the flange from freezing before the center part of the casting and the gate and runner being higher than the casting, the metal will feed through the flange by gravity and will fill the vacancy in the center of the casting. This, of course, will increase the proportion of gates to castings and the cost of melting to some extent, but this will be offset by the reduction in the losses.

In estimating the selling price of good castings, return metal in the form of gates, scrap castings, etc., must be considered. If it is found that even with the increased size of the runners and gates some of the castings still split, this may be taken as an indication that the gates still are too light. Any abnormal increase in gates and runners can be obviated by increasing the thickness of the flange section immediately in front of the gate. This will prevent freezing at this point and will permit of the successful use of a slightly smaller gate and runner. It might be advisable, provided it can be done without increasing the cost of molding, to make the castings flange down. If this can be done, the sand immediately above the cup should be rammed soft. However, we believe that with adequate feeding by gates and runners no trouble from splitting will be experienced.

The metal in the casting is not solid, but is porous and this indicates the need of a deoxidizer. Manganese is the best deoxidizer that can be used for yellow brass and it should be added in small amounts, not sufficient to discolor the castings. A cheaper alloy probably could be used. This should contain more zinc and less lead and it would be advisable to make the mixture from new metals. Knowing the price paid for the scrap, such an alloy can easily be figured, the higher the percentage of zinc and lead, the cheaper the alloy. However, you should keep in mind the fact that high zinc alloys are difficult to cast without aluminum and the addition of a lighter metal will promote casting difficulties.

Effect of Magnesium in Aluminum Bronze

Can you advise us the effect of metallic magnesium in aluminum bronze castings?

The addition of magnesium hardens aluminum bronze and also makes it brittle. However, magnesium also frees the metal from dross, but the decrease in ductility as a result of its use restricts its application as a constituent of aluminum bronze. Chloride of manganese generally is used in making aluminum bronze, as this salt disentangles the metal from the alumina formed by the oxidation of the aluminum. The chloride is added just before the bronze is removed from the fire in the proportion of one ounce per 100 pounds of metal. The addition of 1 per cent of a 30 per cent manganese-copper, free from all iron, also will materially assist in obtaining sound aluminum bronze castings, the use of the chloride also being necessary. The metal should enter the molds without agitation and to accomplish this the casting should be gated so that the metal enters the mold quietly from the bottom.

Fuel Oil Furnace Difficulties

Recently we experienced a great deal of difficulty in operating a fuel oil crucible tilting furnace, using a No. 400 pot. The crucibles break usually after eight or nine heats and it has been suggested that we use this furnace in the form of one of the open-flame type. Fuel oil is used for melting and I would like to know what bad effects could be expected from the use of this furnace as such and whether there is any danger of burning out any part of the alloy contained in the scrap. Furthermore, what chances are there for oxidizing the metal and would the wearing quality of the alloy be reduced if no crucible is used? Our alloy is exceedingly high in sulphur and we would like to know whether this has anything to do with the poor service obtained from the cupola.

This inquiry has been submitted to the makers of crucible tilting furnaces and it is their belief that the difficulty is due almost entirely to the use of a crucible which is too large for the size of the furnace. From eight to 12 heats is about the limit for a No. 400 crucible operating under the condition outlined, while a small crucible would last from 20 to 30 heats.

Also, it is suggested that the burner be changed from the top to the bottom of the furnace and that the pressure of the air be reduced to give a reducing flame at all times. With a reducing flame oxidation will be eliminated, particularly if in connection therewith a flux of ground glass and charcoal be used on the metal. For melting without crucibles the regular single or double chamber open-flame furnace should be used, with air at eight ounces and oil at a pressure of five pounds. Sulphur in the alloy, of course, is a bad feature, as it decreases the life of the crucibles and injuriously affects the alloy. Oxidation, of course, affects the wearing qualities of the alloy. The oxide segregates in spots and causes the heating of the bearings. The use of from 1 to 2 per cent of phosphor-copper will remedy this materially.

Brass Facing Mixture

Kindly furnish me with a suitable sand mixture for facing molds for heavy brass and bronze castings.

For the body of the mold use a sand corresponding to a No. 2 or No. 3 Albany and for facing use equal parts of molding and sharp sand and add a binder the same as when making cores. Flour, dextrin or any other binder can be used in order to make a strong, dry sand mold and plumbago in the form of a wash should be painted over the mold surface.

Blow-Holes in Bronze Castings

We are experiencing a great deal of difficulty in making bronze castings as they develop blow-holes when they are sand-blasted. Our mixture consists of trolley wire, new tin, lead and zinc.

The difficulty from blow-holes in this instance undoubtedly is due to the oxidation of the copper while it is being melted. Trolley wire and all other forms of finely divided copper expose a relatively large surface to oxidation as each piece of copper, as it becomes heated to redness, is covered immediately with a thin film of copper oxide. When this is incorporated in the molten metal it causes gas cavities in the solidifying casting. This difficulty can be overcome easily by careful melting and the following method is recommended:

The trolley wire should be cut to about 12-inch lengths and a crucible ring always should be used in connection with the crucible when the copper is melted. This crucible ring can be made from old crucibles by chopping off their bottoms, using the bottomless rings so formed as hoppers for the crucible when in the fire. The trolley wire should be charged endwise into the crucible after it has been coked and the ring adjusted. The ring should not extend higher than the top of the crucible. The pot should be coked before the ring is adjusted. If the crucible is coked after the ring is adjusted the coke will hold the ring when the pot sinks down in the furnace and thereby a gap will appear between the ring and the top of the crucible through which coke will fall onto the molten metal in the pot. A small amount of salt should be added to the charge when the crucible is filled with copper and later, as the copper melts, its surface should be covered with charcoal. By following these instructions blow-holes will be prevented.

Melting Aluminum for Match-Plates

We are making aluminum match-plates from the No. 12 alloy, but the castings are unsatisfactory. The metal is melted in a crucible in a pit furnace, using coke as fuel. We heat the metal to a cherry red, but it seems to chill rapidly, notwithstanding the fact that the ladles are heated. The metal is porous and seems to shrink away from the sand, which cannot be attributed to the ordinary shrinkage of the metal as we have plenty of risers on the mold. Our trouble evidently is due to the method of melting and pouring and we would be pleased to have you give us some instructions that will enable us to overcome our difficulties.

The porosity of the aluminum is due to overheating while being melted. Cherry red is a temperature near the danger line in melting aluminum, although sometimes it is unavoidable when thin castings are to be poured. While melting, keep the temperature of the aluminum no higher than incipient redness until the pot is filled, when the heat can be brought up to the required point to successfully run the particular castings it is desired to make. This is accomplished by charging fresh metal just before the preceding addition has become entirely liquified and by continuing this operation until the pot is full. Before removing the aluminum from the fire, add a piece of zinc chloride about the size of a walnut to a No. 50 pot and stir to disentangle the dross. With pure No. 12 alloy no trouble should be experienced in running the match-plate if these suggestions are followed.

The excessive shrinkage in this case, however, indicates the presence of a metallic impurity in the aluminum mixture. This impurity probably is iron and it is advisable to have an analysis made to determine this, because if the iron content is more than 0.5 per cent, the alloy is useless for casting purposes. The alloy may be made from remelted scrap, which frequently contains iron.

Use of Silicon in Copper

What benefits are to be derived from the use of silicon in copper and how much should be used? How does magganese affect copper? We would like a good formula for manganese bronze, as well as a mixture for aluminum bronze.

Silicon is used in copper as a deoxidizer and the amount to be employed to produce sound castings will depend entirely upon the amount of oxide dissolved in the metal. Usually 1 per cent of a 10 per cent silicon-copper is required to make solid castings. Therefore, add about 0.09 per cent silicon to the copper, which will reduce its conductivity over 30 per cent. The silicon copper should be added to the molten copper about five minutes before it is removed from the furnace for pouring into castings.

Manganese is an element closely related to iron and chromium. It is grayish white in color, very hard and refractory and as it has a great affinity for oxygen, it is a valuable deoxidizer for other metals not so readily deoxidized. Its use in manganese bronze is for the purpose of deoxidizing the alloy. An excellent formula for manganese bronze follows: Copper, 56 pounds; zinc, 42 pounds; iron, 1½ pounds; tin, 1 pound; aluminum ½ pound and ferro-manganese, ½ pound.

Aluminum bronze is made by melting 90 pounds of copper, to which 10 pounds of pure aluminum are added.

Removing Iron From Aluminum

We have a quantity of aluminum ingots containing a small percentage of iron. Kindly let us know how this iron can be eliminated to enable us to use the aluminum satisfactorily.

Iron cannot be removed from aluminum and the only way in which this material can be utilized is to add sufficient amount of new metal to reduce the iron content to a point where it will do no harm. To accomplish this, it is necessary to determine the iron content by analysis and when this is obtained add sufficient new metal to reduce the percentage of iron. For example, if the iron in the aluminum amounts to 1 per cent, add sufficient new metal to reduce it to 0.25 per cent or less and your charge will consist of 25 per cent of the metal containing iron.

It is altogether possible that 0.25 per cent iron will be found too high for certain aluminum castings, which will be indicated by abnormal shrinkage, and in this case a further reduction of the iron will be necessary. It may be found that 0.15 or even 0.10 per cent iron is as much as can be used. This point will have to be determined by experience and, therefore, only small heats should be made until correct dilution of the iron is arrived at to permit of making perfect castings. Iron causes aluminum to shrink abnormally and, therefore, the amount of this impurity that can be left in the alloy will be governed entirely by the shape of the castings to be made.

Shrinkage of Bushings

Recently we had occasion to make four babbitt metal bushings, 15 inches long, 4½ inches in diameter with a core 3 inches in diameter. They were cast on end and gated on top. When removed from the sand the castings apparently were sound, but after being machined a crack appeared in the castings. It seemed as if the metal had pulled apart. Can you inform us what caused this defect?

The crack was caused by shrinkage, the metal when setting having contracted. As the metal was poured cool, the lower two-thirds of the bushing became comparatively hard while the upper part was in a pasty condition and the crack resulted at this point because of the settling of the bottom part while the upper section was held by the gate on the joint of the mold. This difficulty can be overcome by slicking both the mold and core with plumbago and by gating at the bottom of the mold, taking off a heavy riser at the top to feed the casting as it contracts.

Commercial Classification of Refined Copper

The Why and Wherefore of the Difference Between Electrolytic and Lake Copper is Discussed and Their Properties Defined

By Lawrence Addicks

ANY adequate classification of a material of commerce such as copper must take into account both the limitations of the metallurgical processes by which the material has been obtained and the needs of the manufacturing processes in which it is to be employed. The metallurgical methods depend in turn upon the nature of the ores or other sources of supply and the manufacturing ones upon the ultimate uses of the finished product.

The world's copper supply comes from four main sources, sulphide ores, oxidized ores, native ores and scrap. Perhaps the chief chemical characteristic of copper is its affinity for sulphur and the largest deposits of copper ores consist of more or less complex sulphides. Near the surface these ores are frequently altered to oxides and carbonates by atmospheric influence and there are also large deposits entirely free from sulphur. Native copper ores where the copper exists as free metal occur in various parts of the world in small quantities but notably in the enormous deposits in the northern peninsula of Michigan where they form the source of the so-called lake copper.

Metallurgically there are three typical processes for producing crude or unrefined copper from the ore, based on the general principles of oxidizing sulphides and reducing oxides, (a) roasting, smelting and converting, (b) alternate oxidation and reduction, and (c) direct reduction of oxidized ores. The first method is a strongly oxidizing process by which the great majority of the American production is made from sulphide ores, and results in the almost complete elimination of impurities which have volatile oxides, including some of the worst enemies of refined copper, such as arsenic. Converter bar nearly always runs 99 per cent copper plus silver and is not likely to carry more than a few hundredths of a per cent of any impurity but nickel. The second method is the old Welsh process, still used to some extent abroad, based upon the reaction between copper oxides and sulphides to eliminate sulphur as sulphur dioxide gas and carried out in a long series of roasts and fusions in reverberatory furnaces. The removal of impurities is here imperfect although they may be to a certain extent segregated in a portion of the product, whence the origin of the "Best Selected" copper of Great Britain. When the ores are wholly oxidized the copper may be recovered by direct reduction in a blast furnace and as this is a strictly reducing process the resulting black copper seldom runs over 96 per cent due to iron and other impurities reduced.

Except in the case of "Best Selected" and similar English coppers, all of the products from the foregoing processes are given a further treatment or refining, which may be broadly divided into furnace or fire refining and electrolytic refining.

Fire refining is based upon the scorifying effect of cuprous oxide upon base metals contained in a bath of molten copper. The crude copper is melted in a reverberatory furnace and air blown into the bath. Cuprous oxide rapidly forms and dissolves in the bath, the blowing being stopped at or before the saturation point. In this way oxygen is carried to all parts of the molten bath and when there are any metals present which are more easily oxidized than copper, cuprous oxide is reduced back to copper and the oxide of the impurity is formed. If this oxide is not soluble in the molten copper it will float to the surface where it may be removed by skimming. As copper stands high among metals in the order of nobility the metallic impurities with the exception of the precious metals may be readily removed in theory. In practice while elimination proceeds rapidly while considerable quantities of impurities are present, the rate diminishes until traces are reached which cannot be slagged off with any reasonable amount of scorifying. Therefore, furnace refining is limited in its application to relatively pure crude copper unless a low grade refined copper is contemplated. Less than $10 worth of silver and gold per ton will justify electrolytic refining.

Returning to the bath of molten copper which has been skimmed clean, it is necessary to reduce the excess cuprous oxide dissolved, and no better way has yet been devised than the old Welsh process of covering the bath with a protecting layer of charcoal or low sulphur coke and then forcing the butts of green trees or poles of hardwood beneath the surface by means of suitable tackle. The cuprous oxide is reduced in this way until a normal amount corresponding to an oxygen content of from 0.04 to 0.07 per cent is left when the copper develops its best physical characteristics, the condition of the copper being followed by the appearance of the fracture of small buttons cast in a spoon or "say ladle" which is a sort of ductility test and by the swell or depression of the surface of an ingot as it cools, which indicates the gas content. The copper is then cast by means of one of the several types of ladling machines which have been very successfully developed in recent years.

When the copper is to be electrolytically refined it is first given a rough furnace refining and cast into anode plates, which are then electrolyzed in a strongly acid solution of copper sulphate. The same order of nobility applies, but the great preponderance of copper over the impurities is now an aid as it assists the selective action of the current in depositing only copper at the cathodes. Silver and gold are also saved as they are insoluble in the electrolyte chosen and fall to the bottom of the tank as anode mud or slimes to be separately refined and parted.

It is quite evident that copper entering an electrolytic refinery must entirely lose its identity and that the purity of the resulting cathode copper will depend upon the conditions under which electrolysis is carried out rather than upon the momentary quality of the day's anodes. Therefore, it is not necessary to consider whether the input be converter bar, black copper or lake mineral when buying electrolytic, but simply whether the product meets the accepted standards of quality for electrolytic copper.

Electrolytic cathodes should be very pure. They generally run about 99.95 per cent copper, much of the missing 0.05 per cent probably being hydrogen. The metallic impurities generally total

A paper read at the Chicago meeting of the American Institute of Metals. The author is associated with Phelps, Dodge & Co., New York.

about 0.02 per cent. Except for the fact that individual cathodes may vary more or less in impurity content they are ideal material for brass making. Copper producers, however, have never encouraged the sale of cathodes, as there is apt to be some shrinkage in weight during shipment owing to the comparative ease with which nodules or small pieces can be detached either accidentally or intentionally. Also cathode shipments unbalance the work in a refinery in proportion to their magnitude, as melting cathodes into market shapes is a distinct part of the process.

This melting is done in a reverberatory furnace and originally was an exact duplication of the fire refining already described. As the cathode copper is already pure, a simple melting is all that should be required, but molten copper is so susceptible to contamination that until recently the gases from combustion, iron in the rabbles, etc., were absorbed to a sufficient extent to require actual refining. At the present time large quantities of cathodes are being added to the molten charge during ladling and earlier, basic furnaces are being substituted for acid ones, thereby suppressing slag formation, and attention is being paid to keeping coal ashes from blowing over the firebox, so that a true melting without refining is being approached. It is well known that cathode copper when drawn into wire will show an electrical conductivity some 2 per cent higher than the same copper after a subsequent fire refining. This is probably due partly to the fact that chemical impurities in the cathode are chiefly present as a mechanical mixture due to adherence of anode slimes which are dissolved in the copper when melted, making a high resistance matrix around the copper crystals when the metal is cast and cooled; and partly to contamination during melting. It seems probable that the conductivity of perfectly pure soft copper is in the neighborhood of 103 per cent of the Matthiessen standard in common use.

Lake ores are low grade native copper deposits, which are mechanically concentrated to an 85 per cent mineral. This is melted and after skimming off, the slag formed by the remaining gangue, is given a fire refining as previously described. The Michigan mines are among the oldest, largest and deepest in the world. Thirty years ago lake copper was the standard of the industry. The surface ores were remarkably free from objectionable impurities and copper of the highest conductivity was readily produced. The first electrolytic copper to come on the market was of irregular character due to lack of familiarity with the principles of this new process and for a considerable time lake copper was deservedly considered superior. With increasing depth, however, many of the mines showed increasing quantities of arsenic and indeed all lake copper may be considered as arsenical copper, although in some brands the arsenic is very low. The result was that electrolytic copper began to take precedence for electrical work, as its conductivity could be absolutely depended upon, and lake began to fall back upon superior "working" qualities, a term which defied exact definition. It is now generally admitted that high conductivity lake copper cannot be distinguished from electrolytic copper, while low conductivity lake is really an alloy of copper with arsenic which has certain desirable properties for special uses. Nearly all the elements which markedly depress the conductivity when alloyed with copper are helpful in developing desirable mechanical properties, for example, phosphorus, aluminum and silica. High arsenical copper running about 0.4 per cent arsenic has now a special market for making firebox plates in Germany, and uses are beginning to be found for the intermediate grades. One of the large lake companies maintains its own electrolytic refinery, and in this way recovers a small amount of silver and eliminates the arsenic, the product still being classed on the market as lake, although it is equally electrolytic. The old prejudice in favor of lake on general principles has now largely died out but only with the contemporaneous retirement of the older generation of wire mill managers. Lake copper should be clearly graded by arsenic contents into a series of alloy coppers, the class at one end competing with electrolytic on its own ground, and the other classes sold in competition with arsenical copper from other sources, a field which has only lately been properly appreciated.

The last class of copper produced which we have to consider is that generally known as casting copper, a very loose term covering a multitude of sins. There are three main sources of casting copper (a) from converter bar or black copper from smelters whose ore supply carries quantities of silver and gold insufficient to pay for refining, (b) by-product copper not up to standard electrolytic grade occasionally produced by refineries, and (c) the result of smelting scrap reclaimed from all sorts of new and old work. The first is often of excellent quality, one well known brand being maintained at 99.80 per cent copper or better, and is generally comparable with English Best Selected. The second class is generally an arsenical copper and is not now often seen as the refineries are nowadays able to eliminate arsenic from the process in other ways. The third class is generally foul, but often suitable for common castings as the impurities help the founding, pure copper being a difficult metal to handle in a foundry. The copper contents may, however, run below 99 per cent.

Specifications for lake and electrolytic copper may be readily drawn and after a thorough investigation the American Society for Testing Materials has issued a set which should be generally accepted by engineers, as it has already been by the large refineries and wire mills. Casting copper presents a specification problem hopeless of solution at the present time, as there are well-known brands in the market with the widest imaginable range of impurities, all of which are being kept consistently within a certain range of quality for each individual brand and which find a market for various uses. About the one thing that can be said of casting copper is that neither a conductivity nor a ductility test is applicable in the nature of things.

Turning now to the uses for copper, they may be broadly classified as follows: (a) wire and other shapes for electrical purposes; (b) sheets and plates for non-electrical uses; (c) copper castings, generally for electrical use; (d) in alloys such as brass and bronze; (e) special purposes for which small quantities of alloyed impurities may be advantageous.

Electrical use immediately imposes a conductivity requirement which rules out everything but electrolytic and high conductivity lake, which, as before stated, are practically identical coppers. Most of the electrolytic refineries figure on averaging about 100 per cent soft in the electrical conductivity of their outputs. Occasional lots may reach nearly 101 per cent, and some may approach 99 per cent, while 98.5 per cent is the usual rejection limit, but it is very unusual for a refinery to ship anything for electrical use which is below 99 per cent. No distinction is made between cakes, wirebars and ingots, more than one shape often being cast from a single furnace charge, so that there is nothing to be gained by ordering wirebars and then cutting them up, when ingots are desired. Unless electrical use is specified it is customary to allow an addi-

tional leeway of 1 per cent in conductivity to the refiner, but he rarely needs this and prefers to maintain the higher standard, as copper is often resold several times before it comes into the hands of the actual user. As copper from a single furnace charge will carry practically uniform chemical impurities, shipments on an individual order should be filled from as few furnace charges as possible and all wire bars and cakes should be stamped with marks identifying these charges. The refiner will always consider complaints on a furnace charge basis if they are of a chemical nature. If they are indefinite he will generally investigate what other customers received copper from the charge complained of, and in the absence of other complaints will demand a bill of particulars before giving the matter serious consideration. The conductivity of a furnace charge is generally determined at the refinery several times while the charge is being cast and this precaution together with the ample margin above rejection limits which is maintained, have practically abolished conductivity complaints.

When copper is not to be put to an electrical use conductivity is of no special value as a certificate of the absence of more than a trace of a certain class of impurities. The refiner divides impurities into three classes; those that depress conductivity, such as arsenic and antimony; those that impair ductility, such as lead, tellurium and bismuth; and those which are of value if reclaimed, such as silver, gold, platinum and palladium. The elements which depress conductivity are kept within bounds by the conductivity test regularly made. Those which are of value if reclaimed will never reach quantities sufficient to affect the physical properties of the copper as it would pay to re-refine any such copper. The remaining class comprising elements which impair ductility is more difficult to deal with. We know that bismuth, lead, tellurium and probably selenium make copper very brittle even when present in very small quantities. We do not know, however, how to write a specification limiting these impurities as the presence of small amounts of other impurities will neutralize their bad effects. We do know that amounts of lead up to 0.005 per cent have no perceptible effect in mill practice or in alloys. Double this amount shows mild effects. Lead is about the only one of the group ever met with in sufficient quantity to be of interest. As these elements are practically insoluble in copper their effect on the conductivity is directly proportional to the amount present and consequently negligible.

It must be understood that an element like lead is always present in small amounts in refined copper and the mere fact of its presence as shown by a delicate qualitative test is no basis for complaint. It should be further borne in mind that the determination of the small quantities of impurities in refined copper quantitatively can only be done with even reasonable accuracy by a chemist who has had large experience in this particular work. A representative analysis of refined electrolytic copper would be somewhat as follows:

	Per cent.
Conductivity (annealed)	100.0
Copper	99.93000
Silver	0.00100
Gold	0.00001
Sulphur	0.00300
Oxygen	0.04000
Iron	0.00350
Nickel	0.00400
Arsenic	0.00200
Antimony	0.00300
Aluminum	0.00100
Phosphorus	Trace
Lead	0.00200
Bismuth	Trace
Selenium	0.00050
Tellurium	0.00050
	99.99051

It will be seen that oxygen is the chief impurity. It has been pretty conclusively shown that too much oxygen makes the copper harder and affects the annealing temperature, the tensile strength of wire and the number of breaks in a wire machine. This may be due to some surface effect as the "set" surface of a wire bar has a greater oxygen content than the body of the bar and as the oxygen content increases it is possible that this oxidized layer becomes thicker. Another point about high oxygen is that it corresponds to low copper contents and to that extent is sold as copper. In brass making the "set" or "pitch" of the ingot is of no consequence except when the most careful work is done when melting in the foundry to avoid further absorption of oxygen. It is obviously useless to impose rigid conditions upon the refiner if the same conditions are not observed in the remelting and it is only at the largest and best equipped brass foundries that such conditions are even approached. When zinc is introduced into molten copper it acts as a deoxidizing agent forming zinc oxide. If the copper is kept at very high pitch this source of zinc loss and dirty brass can be greatly diminished and this fact has resulted in a demand for high copper contents in ingots.

It has, therefore, become a general custom to specify that the copper contents of refined copper shall not be less than 99.88 per cent, which really means 99.90 per cent, allowing 0.02 per cent for assay variations. As this is a rejection point the actual average content is expected to be between 99.92 and 99.94 per cent.

When we come to casting copper a far greater leeway must be allowed as already pointed out. In fact, except in considering the price charged for the material, copper contents has but little to do with casting copper. It is best to buy this material on the basis of known brands after finding what brands yield good results in the particular class of work and then insist upon uniform deliveries, judging the material by chemical analysis of the chief impurities.

The physical defects of refined copper are many. Practically all cast copper is porous, doubtless due to the discharge of dissolved gases as the copper cools.

This is analagous to the "piping" of steel ingots but is not so pronounced because copper is cast in a shallow mold instead of on end. These microscopic bubbles are doubtless the cause of roughness in wire. Then there is a class of defects inseparable from ladling, consisting of cold sets and splashes where the copper has run up on the mold and chilled before the main body of metal reaches that point. Then there is porosity or sponginess of the surface due to the mold being either too hot or too cold. Another defect is raised edges on the set surface, generally due to slightly lowered pitch corresponding to excessive oxygen content of the copper. Should the pitch drop still lower "nigger heads" or little black spots will appear. These are the outlets of gas cavities extending some distance into the copper. On the other hand should the oxygen content be too low the surface of the bar rises and finally breaks open or "spews", an even worse condition.

Many of these defects are always present in more or less degree. Mechanically ladled copper can never be perfect. Specifications require that copper shall be free from mechanical defects, but a reasonable attitude regarding minor troubles on individual pieces is generally necessary to the peace of mind of a buyer. On the other hand a refinery occasionally becomes careless in such matters and will send out some surprisingly bad work, so that careful systematic inspection combined with an attitude of friendly criticism is the best way for a copper producer and a copper user to live together.

Protective Coatings for Iron and Steel---II

By E P Later

REGARDING the methods of application, the hot dip process is widely used and is probably familiar to all platers. It involves thorough cleaning and pickling of the parts, dipping in dilute hydrochloric acid, drying and immersion in a bath of molten zinc. A flux, which is generally composed of sal-ammoniac, sometimes moistened with glycerine, is used to promote the production of a smooth and perfectly adherent coating. The parts are finally removed, and the excess zinc shaken or scraped off, after which they are cooled in water or in the air.

By this method a heavy coating of zinc is produced, ranging from about 150 milligrams per square inch up to 300-400 milligrams, but the weight cannot be controlled as easily as in the plating process. Such a coating will resist the weather for years, under ordinary circumstances, and if protected by a good paint should last indefinitely.

It is apparent, however, that this method has certain disadvantages which restrict its use considerably. For instance, parts having fine threads, small holes, etc., could not be dipped, as these would be filled up. Then, too, such a coating increases the dimensions of the part materially, so that in cases where accuracy in this respect is required, hot galvanizing would not be applicable. Further, the deposit is liable to be thicker at some parts of the surface than at others, due to runs, a condition which might be objectionable. Lastly, the temperature of the bath, between 850 and 900 degrees Fahr., would injure, in one way or another, many parts. The process has the saving virtue of cheapness, however, and in places where the above objections do not count it can be used to an excellent degree of satisfaction. There are several ways in which the weight of a hot dip coating can be estimated. The zinc may be removed by acid and determined by appropriate chemical methods or a part may be cleaned and carefully weighed, then placed in a strong, hot caustic potash solution until the zinc is entirely taken off, after which it is washed, dried and reweighed. Dividing the difference between the two weights by the area in square inches and moving the decimal point three places to the right the result is expressed as milligrams of zinc per square inch. Such a procedure is too slow for practical commercial work, however, so what is known as the Preece test is in extended use.

Weight of Hot Dip Coating

It is based on the fact that both zinc and iron are soluble in a strong solution of copper sulphate, metallic copper being thrown out as the other metals go into solution. The rate of the reaction varies considerably, zinc precipitating the copper very rapidly while iron does so comparatively slowly. When, therefore, a piece of galvanized iron is immersed in a strong copper solution, a black, loosely adherent deposit of copper, which can be easily wiped away, is formed on the zinc while a corresponding amount of the latter is dissolved and goes into solution. When it is all removed, however, the copper deposits on the iron as a more or less bright metallic coating which is fairly hard and difficult to remove. The appearance of such a coating is an indication that the zinc deposit has failed.

There are several factors which influence this test greatly, but it has been pretty carefully standardized, several firms have issued very specific and exact directions for carrying it out, so there is uniformity in its operation.

Briefly, these directions call for a solution of copper sulphate which has been neutralized with pure copper oxide and possesses a specific gravity of 1.186 at 65 degrees Fahr. During the test, the temperature must not fall lower than 65 degrees Fahr., nor go above 70 degrees Fahr. The galvanized parts are carefully cleaned and immersed in the solution for exactly one minute, then removed, washed and wiped dry with a rag. Ordinarily, wire and other material are required to stand four dips without showing a deposit of metallic copper. Accordingly, the parts are dipped the required number of times and then carefully examined. The whole coating is more or less blackened, but with a little experience a true copper deposit can be easily detected, when it is present, and if it appears after four dips the parts are rejected.

It will be noted that such a test really measures the thickness of the coating at its weakest point and does not, of course, give the actual number of milligrams of zinc per square inch, but as a ready and quick means of determining whether the minimum deposit has been obtained, it is very useful.

Electro-galvanizing is finding wide application in various lines and it is now possible to produce very satisfactory deposits, although it is only within comparatively recent years that such has been the case. Zinc plating baths are essentially a solution of zinc sulphate with a very small amount of free sulphuric acid, boric acid and certain organic substances. There are several patented or secret compositions on the market which are giving good results.

(*Continued on page* 40.)

A Sand Blast and Steel

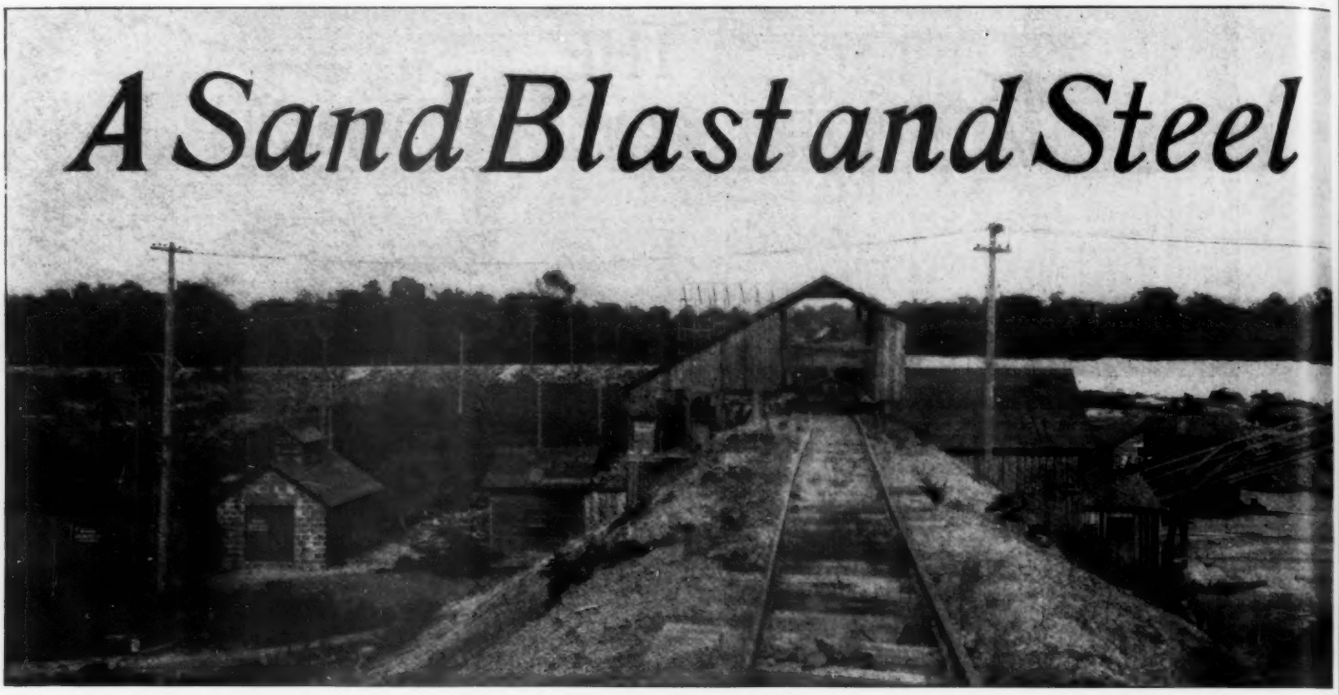


Fig. 1—Plant of the Portage Silica Co. in Portage County, O. where

How the Portage Silica Co. Prepares Its Product

WITH the introduction of the sand-blast, foundry cleaning operations have undergone a tremendous change in the last decade. By the projection of sand, or more correctly, silica pebbles with the aid of an air blast, against the surface of castings, they are cleaned more effectively than by any method other than pickling. However, the development of every new device is fraught with some difficulties, and in the case of the sand-blast machine a satisfactory and adequate supply of sand was not available to meet the needs of the foundries installing this equipment. Beach sand from the New Jersey coast for a number of years was used almost exclusively for this purpose, but the freight on shipments to the central and western states added to the cost of this material and in a measure retarded the introduction of sand-blast machines in many shops. Many efforts were made to adapt crushed silica rock to this work, but it was found that the silica pebble in its natural state gave the best results and was not so quickly reduced to a powder as a result of the abrasion with the casting.

Two points of attraction in Portage County, O., are known as Nelson Ledges and Newell Ledges, respectively, which consist of unsual outcropping of rock, defined as a conglomerate and consisting of silica pebble in a matrix of silica sand. By crushing this conglomerate the material is merely disintegrated, the pebbles retaining their natural contour. The high silica content of these pebbles, it was found, would lend themselves admirably to sand-blast operations and the silica sand was an ideal material for molding steel castings. Cleveland and Youngstown business men became interested in the exploitation of this product and early in 1909, the Portage Silica Co. was organized, with headquarters at Youngstown, for the purpose of developing 900 acres of this property

FIG. 2—THE DRYING PLANT

FIG. 3—ANOTHER VIEW OF THE PORTAGE PLANT

Molding Sand Plant

Sand-Blast Sand and Steel Molding Sand is Recovered from a Conglomerate Rock

to Meet the Requirements of the Foundry Trade

which had been acquired in Portage county, near Garrettsville, O. A survey has proved up 20,000,000 tons of this conglomerate on this tract, which is a sufficient supply for 100 years at an annual mining rate of 200,000 tons.

At some points this conglomerate is approximately 100 feet deep and the vein has an average width of one-quarter of a mile. The top soil overlaying the vein is rarely more than four feet deep and this is stripped to permit of open cut mining with a steam shovel. The conglomerate first is blasted, after which it is loaded into cars by the steam shovel and conveyed to the plant where is it crushed, washed and screened. As pointed out previously, the conglomerate is crushed merely to disintegrate the material and in this operation the original contour of the pebble is not affected. Crushing the pebbles develops internal strains which causes them to break easily in sand-blast operations. The silica content of the pebble itself is nearly 100 per cent and the washed pebbles, in bulk, show an average analysis of 99.5 per cent silica. The steel molding sand averages 98 per cent silica, although as high as 98.65 per cent silica has been shown, as indicated by the following analysis: Silica, 98.65 per cent; oxides of iron and aluminum, 0.85 per cent; carbonate of lime, 0.35 per cent and carbonate of magnesia, 0.10 per cent.

The pebbles vary in size from 1 inch to ½-inch and less, the latter constituting the steel molding sand. The largest pebbles, namely from ¼ to 1-inch are used in concrete work; pebbles from ¼ to ½-inch are employed in concrete road work and sizes from 3/16 to ¼-inch are used for making concrete steps subjected to great wear and also form an ideal wearing surface for roads in conjunction with a bituminous binder.

Pebbles from ⅛ to 3/16-inch constitute the sand-blast sand and this is screened to five different sizes to meet

(*Continued on page* 41)

FIG. 4—A VIEW OF THE QUARRY

FIG. 5—MINING WITH STEAM SHOVEL

THE FOUNDRY

A monthly journal devoted to all branches of the foundry trade.

Published by

The Penton Publishing Co.

Penton Building, CLEVELAND

BRANCH OFFICES

BIRMINGHAM, ENG. - - - - Prince's Chambers
CHICAGO - - - - 1521 Lytton Bldg.
CINCINNATI - - - 503 Mercantile Library Bldg.
NEW YORK - - - 507 West Street Bldg.
PHILADELPHIA - - 326 Real Estate Trust Bldg.
PITTSBURGH - - - - 2148-49 Oliver Bldg.
WASHINGTON, D. C. - - - 206 Corcoran Bldg.

SUBSCRIPTION

United States and Mexico - - - - $1.00 a year
Canada - - - - - $1.50 a year
Great Britain and other Foreign Countries Eight Shillings
Single Copies - - - - - 15 cents

Copies published three months or more previous to date of current issue, 25 cents each.

ADVERTISING

All communications relating to advertising copy, discontinuances, etc., must be received on the 10th of the month preceding date of publication.

ENTERED AT THE POST OFFICE AT CLEVELAND AS SECOND CLASS MATTER

Copyright, 1914, by the Penton Publishing Co.

Contents

ELECTRIC STEEL CASTINGS MADE ON LARGE SCALE 1
REVISION OF THE A. F. A. STANDARD COST SYSTEM 7
AN ANALYSIS OF THE FOUNDRY COST 8
NOVEL TESTS OF MALLEABLE CAST IRON 13
FIFTY SAFETY RULES FOR THE OPERATION OF CRANES 16
SOME POINTS ON CUPOLA PRACTICE 17
MOLDING AIR COMPRESSORS ON JOLT-RAMMERS 18
WOULD THE CASTINGS HAVE COME STRAIGHT? 19
PIN HOLES AND INTERNAL SHRINKAGE 19
SLOW MELTING 20
MELTING STEEL TURNINGS 20
TO AVOID CHILLING 20
CORE MIXTURE FOR STEEL CASTINGS 20
OPERATING A FOUNDRY ON A SCIENTIFIC BASIS—III 21
USE OF RELIEF VALVES ON CUPOLA BLAST PIPES 26
REGULATING THE HEIGHT OF FUEL BEDS IN CUPOLAS 28
FOAMING SLAG 28
DIFFICULTIES WITH YELLOW BRASS TRAP COVERS 29
EFFECT OF MAGNESIUM IN ALUMINUM BRONZE 30
FUEL OIL FURNACE DIFFICULTIES 30
BRASS FACING MIXTURE 30
BLOW-HOLES IN BRONZE CASTINGS 31
MELTING ALUMINUM FOR MATCH-PLATES 31
USE OF SILICON IN COPPER 31
REMOVING IRON FROM ALUMINUM 31
SHRINKAGE OF BUSHINGS 31
COMMERCIAL CLASSIFICATION OF REFINED COPPER 32
PROTECTIVE COATINGS FOR IRON AND STEEL—II 35
A SAND BLAST AND STEEL MOLDING SAND PLANT 36
FOUNDRY TRADE IN RETROSPECT 38
METALLIC PASTES FOR TEMPERATURE MEASUREMENTS 39
WET AND DRY GRINDER 39
USE OF HERMAN MACHINES 39
PIG IRON CHARGING CAR 40
BRASS MELTING AND REFINING FURNACE 40
DETROIT FOUNDRYMEN'S ASSOCIATION 40
A NEW GOGGLE FOR GRINDERS 41
PERSONAL 41
GENERAL INDUSTRIAL NOTES 42
NEW TRADE PUBLICATIONS 42

Foundry Trade in Retrospect

TURNING back the pages of the twelve-month period which has just come to a close reveals a feeling of hopefulness and a spirit of optimism at the beginning, which foreshadowed a return of prosperity in the foundry industry. The buying of pig iron during the months of January and February indicated heavy melting in all the casting shops and foundrymen generally anticipated capacity production. Early in the spring the clouds of unfriendly business legislation began to gather and large buyers, such as the railroads, mining companies and allied interests issued orders to defer buying until the sky had cleared. Many large industrial projects also were held in abeyance until this legislation was enacted, as the measures threatened to be so drastic, that the business life of some corporations seemed to be threatened. Early in the summer months, when the legislation assumed more definite form and it was ascertained that the measures were not to be so drastic as first indicated, the shock of the European war disrupted all trade currents and trade began a sharp decline which reached its low point in November. Following the election, which reflected the attitude of the country toward the national administration, feeling generally improved and buyers again manifested an interest in placing orders for their immediate requirements. The low prices prevailing for pig iron led to the placing of large contracts extending through the first half of 1915, and it was estimated that more than 1,000,000 tons were sold during this movement. Early in December another falling off in the volume of business became manifest, but the decision of the Interstate Commerce Commission granting the eastern roads permission to increase freight rates 5 per cent developed a more optimistic attitude toward the future and at the close of the month a remarkable increase in inquiries was reported in almost every line of business. Almost immediately after the decision was rendered the railroads began to place orders for cars and rails and it is evident that the rate increase will enable them to finance their affairs to permit of the purchase of much needed equipment. With the belief general that bottom has been reached and that business again is mounting the upward curve, better trade conditions are forecast for the ensuing year than prevailed in 1914. While the improvement may not be as rapid as might be desired, nevertheless a more hopeful feeling exists than at any time in the last two and a half years. The foundry melt, particularly during the last six months, suffered in proportion to the decline in the iron and steel trade and in some branches of the industry, production was not greatly in excess of 25 per cent of the capacity. The heavy buying of machine tools by the belligerent nations revived many of the machinery shops and plants specializing in work for the automobile and motor truck industry are being hard pressed for shipments. As might be expected, the capacities of foundries were not greatly increased and new construction was limited. Pig iron prices, already low at the beginning of the year, suffered further declines and the low points were reached at both Buffalo and Chicago, where it is reported that large sales were made below $12. However, the market has since reacted slightly and today's quotations follow: No. 2, Pittsburgh, $13.70; Cleveland, $13.25; Chicago, $13; Philadelphia, $14.25; Buffalo, $13, and Birmingham, $9.50. Malleable iron is held at $13, Chicago and Buffalo, and basic at $13.45, Pittsburgh, and $13.50, eastern Pennsylvania.

Metallic Pastes for Temperature Measurements

A new method for measuring temperatures has been developed by the Carl Nehls Alloy Co., Detroit. This consists of the use of different kinds of metallic salts which are made into molecular mixtures that will melt down at different temperatures, throughout the range between 220 and 1,330 degrees, Cent. Practical means have been devised for using them in place of pyrometers. They also are useful for checking pyrometers. In this case a cylinder of paste is placed at the end of the thermo-couple and when it melts the pyrometer should read the same as the temperature indicated by the paste.

One method of using the paste is to cast it into solid cylinders, 7/16-inch in diameter and ¾-inch long, as shown at *A* and *B*, Fig. 1. Each is wrapped in a paper, on which is printed its correct melting temperature in degrees Cent. For all temperatures below 932 degrees Fahr., these cylinders can be inserted in an air-tight glass tube, shown at the center of Fig. 1. The salts then can be used over and over again. By using small porcelain saucers, the salts will not waste and they can be used repeatedly, as the salts melt each time the temperature rises above the one marked on the cylinders and become solid again the moment the temperature falls below this degree of heat.

These salts also are sold in the form of a paste. A sufficient amount to

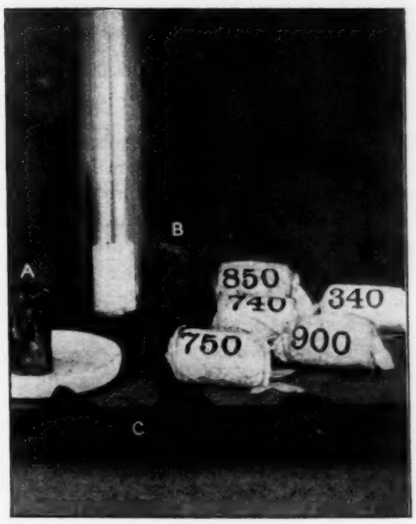


FIG. 1—CYLINDRICAL PASTE PYROMETERS

make several hundred determinations is packed in tin cans. Pastes with varying melting temperatures can be daubed along a steel bar, as shown at *C*, Fig. 1, and this can be inserted into furnaces, ovens, retorts, flues, gas mains, steam pipes, etc., to find the temperatures at which they are operating. The temperature will be between the salts that melt

FIG. 2—PASTE PYROMETERS USED IN TUBES IN A FURNACE

and those that remain solid. By using a long bar one can determine whether the temperature is uniform in the front and back, top and bottom, or corners of a furnace, oven, kiln, etc.

To ascertain the exact temperature of tools heated in a forge fire, a paste is selected that represents the correct hardening temperature for the tool. This is daubed on the tool and when it is heated to this temperature the salt will melt and the tool can be taken out of the fire and quenched.

Another method of using these cylinders is shown in Fig. 2. At *A* are two tubes or pipes with plugs in their ends. Cylinders of different melting temperatures are dropped into the tubes and rods *B* are set on top of these cylinders. When the salts melt the rods will lower. When one rod is lowered and the other remains stationary, the temperature must be between the melting temperatures of the two salts chosen. These may be only 10 degrees apart. This method is useful for finding the temperature of molten metal, salt bath furnaces, etc.

These molecular mixtures of metallic salts can be used for ascertaining the temperatures of molten, cast, rolled, forged or heat-treated metals; in baking, enameling, japanning and other ovens; distillation retorts; for flue, chimney, producer and other gases; gas engine exhausts, etc.

Bulletin No. 42,800, recently issued by the General Electric Co., contains a reprint of an article appearing in the *General Electric Review*, covering electrically driven air compressors in foundries. This bulletin compares centrifugal compressors with the ordinary fan and the positive pressure blower.

Wet and Dry Grinder

A machine designed for both wet tool grinding and rough dry grinding recently has been developed by the Challenge Machine Co., Philadelphia. It has a single spindle supported by a heavy cast iron pedestal, the two wheels being carried on the ends of the spindle in the usual manner, as shown in the accompanying illustration. The water is carried in a pan which may be removed permitting the use of a plain wheel in place of the wet wheel. The supply of water is controlled by a foot treadle. A light pressure on the treadle raises the front end of the pan, bringing the surface of the wheel in contact with the water. The water carried up by the wheel is returned to the pan through the open bottom of the apron. The guard for the dry wheel is made up of channel steel forged to shape. It is open underneath the wheel and the upper member may be easily removed to permit grinding on top of the wheel. The guard may be adjusted vertically and horizontally close to the wheel. The eye shield is detachable and is fitted with a wire glass screen.

Use of Herman Machines

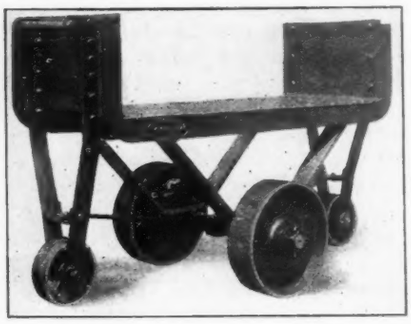
In the article entitled "Making Boiler Sections on Molding Machines," published in the November issue of THE FOUNDRY, in which reference was made

COMBINATION GRINDER WITH WHEEL GUARD

to numerous types of molding machines, specific mention was omitted in regard to the use of molding machines made by the Herman Pneumatic Machine Co., Zelienople, Pa. A large part of the work in the H. B. Smith Co.'s boiler section foundry, which this article described, is made on machines of the Herman type.

Pig Iron Charging Car

The National Brake & Electric Co., Milwaukee, has recently installed a number of new pig iron charging cars in its foundry, one of which is shown in the accompanying illustration. They were designed by the Orenstein-Arthur



PIG IRON CHARGING CAR

Koppel Co., Koppel, Pa. No track is needed for the car and it can be run anywhere on the floor. On account of the end wheels being higher than the center ones, the car can be balanced and turned in its own length on the center wheels. The platform is made just wide enough so that the pigs of iron can be piled crosswise, and they will project enough so that they can be easily taken hold of.

Brass Melting and Refining Furnace

A furnace, specially designed for melting brass and other non-ferrous metals in crucibles, recently has been placed on the market by F. M. Iler, 242 West Florida avenue, Denver,

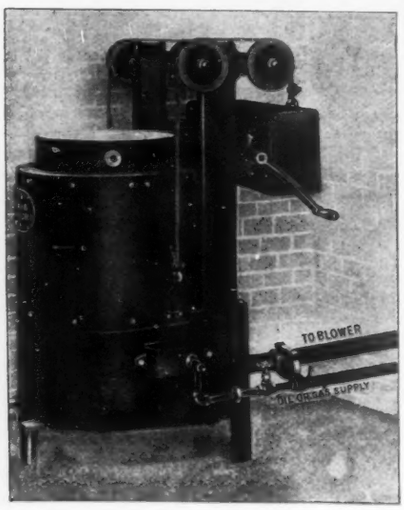


FIG. 1—DRAW CRUCIBLE FURNACE CLOSED

Colo. It is designed to use either gas or oil fuel and is adapted, it is said, for both melting and refining operations. The furnace, as indicated in the accompanying illustrations, consists of two parts, a combustion chamber and a crucible chamber. An air-tight seal is formed between the two chambers when the furnace is closed. The furnace designed for a No. 60 crucible is 34 inches high and occupies a floor space of 8 square feet. It is provided with a swinging cover on the top through which access may be had to the crucible for stirring or making additions to the charge.

When the crucible chamber is hoisted away from the combustion chamber, the crucible is exposed and may be easily removed by the use of an open-sided shank, as shown in Fig. 2.

The air in its passage from the blower to the burner is forced through a conduit in the walls of the combustion and crucible chambers, pre-

FIG. 2—DRAW CRUCIBLE FURNACE OPENED TO REMOVE CRUCIBLE

heating it to a high temperature. The flame enters the chamber tangentially, swirls about the stool and crucible and is said to completely fill the space around the crucible. The temperature of the air at the burner, according to pyrometer tests, is said to be 450 to 550 degrees, while the temperature of the brass melted is maintained without difficulty at 2,100 degrees and much higher temperatures, up to 2,700 degrees, have been reached in melting steel.

Detroit Foundrymen's Association

At a meeting of the Detroit Foundrymen's Association, held Dec. 10, C. G. Smith, president and general manager, Pittsburgh Emery Wheel Co., Pittsburgh, gave an address entitled "The Increased Efficiency and Economy Obtained by the Introduction of Safety Devices in Grinding Practice". Mr. Smith is a member of the safety board of the state of Pennsylvania, and brought out many interesting points during his discourse.

Protective Coatings for Iron and Steel—II

(Continued from page 35)

The successful operation of a zinc solution requires considerable care, as it is liable to prove troublesome at times. It does not *throw* very well and difficulty is generally experienced in getting a sufficient deposit in the corners and recesses of irregularly shaped parts. On the other hand, it is free from some of the objections encountered with the hot dip process, that is, it does not fill up threads nor increase dimensions any more than does plating with other metals and, weight for weight, a deposit of electro-zinc is the equal, in protective power, to the coating which is produced by the hot process. It seems to be the present practice to apply a coating ranging around 100 milligrams per square inch, to all parts on which thorough protection is required. Of course, the explanation of the way in which a zinc coating protects iron applies equally well to the electro deposit.

The weight of the coating may be determined as given under the hot dip process. Probably the quickest way is by stripping in strong, hot caustic, as previously explained, although the copper sulphate test may be used to advantage in routine work.

Sherardizing

The third method, sherardizing, by which a zinc coating can be produced, is of fairly recent origin and a good deal of work is being done to improve it, although it must not be inferred from this that it is not a commercial success at present. It consists, briefly, in placing the parts in a

large iron drum together with a quantity of zinc powder, which is composed of varying amou of zinc and zinc oxide. The dru placed in a furnace heated by ga or electricity and the temperature raised to approximately 800 degrees Fahr., maintained at that point for some time, and then the drums are allowed to cool. The whole process requires several hours. During this time the zinc is not melted, but in some way, it is impossible to give here the theories and views regarding the mechanism of the action, the iron and zinc unite with the production of a very resistant coating on the surfact of the parts. This coating apparently consists of a series of layers of zinc-iron alloys, those richest in iron being deepest, while the outer layers of a very thick deposit are practically pure zinc.

The protective power of a sherardized coating is very high, but it is not so good as some enthusiasts have fondly claimed.

Whether or not it is better, weight for weight, than a hot dipped or electro-galvanized coating is probably open to serious doubt. There is one point, however, which has doubtless tended to prejudice the casual observer against it. This is the fact that a sherardized part when exposed to severe moisture conditions soon develops a reddish color, closely resembling rust. This is due to the oxidation of part of the iron in the coating and is called the *curing* color. On continued exposure, the surface turns very dark, probably from the formation of ferric oxide, which possesses considerable protective power.

Advantages of Sherardizing Process

Compared with the electro and hot dip methods, sherardizing presents certain advantages. For instance, it is applicable to very small parts, those having threads, holes, etc., and in cases where the hot method is of little or no value. Again, a very uniform deposit is produced on all surfaces, inside and out. Any place to which the powder has access will receive a coating. This constitutes perhaps the most marked superiority over electro-galvanizing, since in connection with the latter process it has been noted that difficulty is often experienced on inner surfaces. Naturally, parts which cannot stand very much heat might be injured by sherardizing; this point would have to be determined for each individual case.

The weight of the coating can be determined, as before, by stripping in caustic soda. The Preece test also is applied to sherardized material and, although it has been severely criticized there seems to be no reason why it should not give satisfactory results, when certain precautions and modifications are observed. One of these is the substitution of a stiff brush for the rag in cleaning the samples after dipping, for it appears that only this can properly remove the copper which is deposited on the zinc or zinc-iron alloy and does not constitute the true metallic deposit.

In conclusion, it may be well to note that sherardizing is a patented process and a royalty must be paid for the privilege of using it.

A Sand-Blast and Steel Molding Sand Plant

(*Continued from page 37.*)

the varying requirements of the foundry trade. In the accompanying illustration, Fig. 1 is a view of the crushing, washing and screening plant. The cars filled with the conglomerate rock are delivered by locomotive to the crusher building where the material is disintegrated in a machine of the squirrel-cage type. The crushed material then is conveyed by belt to the screening and washing house, where it is washed and screened at the same time. The screening equipment consists of three sets of three screens each, the material being divided into five sizes including the molding sand which is deposited in the settling tank. This tank is 12 feet long, 6 feet deep and 3 feet wide, the molding sand settling to the bottom with the dirt overflows.

With the exception of the sand-blast sand, the other sizes are conveyed to stockpiles, ready for shipment. The sand-blast sand is carried by a belt conveyor to the dryer house where it is dried in a four-compartment, C. O. Bartlett & Snow dryer. The sand then is delivered by a belt conveyor to screens where it is divided into five sizes and is deposited in bins ready for shipment to the foundry trade. The steel molding sand recovered in the settling tank contains very little fine material, less than 3 per cent passing through a 100-mesh sieve.

At present this plant has an annual capacity of 120,000 tons with facilities for shipping 25 to 30 cars daily. When necessary, these shipments can be further increased to meet the urgent requirements of the foundry trade.

The officers of the Portage Silica Co., follow: J. G. Butler Jr., president and treasurer; E. E. Klooz, vice president and general manager, and L. R. Farrell, secretary. C. M. Bixler is sales manager.

A New Goggle for Grinders

A new goggle especially designed to meet the requirements of machinists and grinders is now being offered to the foundry trade by T. A. Willson & Co., Inc., Reading, Pa. It is designed to afford workmen complete comfort and perfect eye protection and by the use of a special frame the goggle is made light in weight, although substantial in construction, due to the sturdy eye wire, temples, etc. An adjustable bridge enables the wearer to easily fit the glasses to his face. This bridge is pliable and is securely attached to the eye wire. The bridge does not touch the top of the nose, the weight of the glasses being distributed over the sides of the nose and the cheeks. Since the bridge does not rest on the nose the glasses can be worn over spectacles. Since it is important that grinders and machinists be protected from dust, emery and grit, side guards are necessary and on these goggles a light, fine-mesh wire gives ample protection. A fine quality glass is used in the goggle to insure freedom from eye-strain. As the metal frame of the goggle is rust proof, the goggle remains sanitary and can be thoroughly sterilized. Comfort further is assured by the flexible half cable temples, which easily conform to any face and do not pull or cut into the ears.

Personal

H. A. Beach has been appointed secretary-treasurer of the Wing Foundry Co., Columbus, O.

James Fox, formerly superintendent of the foundry operated by the Best Mfg. Co., Pittsburgh, on Jan. 1, will become affiliated with the Union Switch & Signal Co., Swissvale, Pa., in a similar capacity.

W. B. Scott has resigned as foundry foreman of the Rodney Hunt Machine Co., Orange, Mass., to accept a position as foundry superintendent of the Flather Foundry Co., Nashua, N. H.

James C. Peil has resigned as foreman of the molding department of the South Works of the J. I. Case Machine Co., Racine, Wis., to accept a position as superintendent of the foundry of the Maxwell Motor Car Co., Dayton, O. For more than 16 years Mr. Peil was superintendent of the Pierce Machine Co.'s foundries, which subsequently were purchased by the Case company. Mr. Peil was tendered a banquet by his fellow employes of the J. I. Case works and was presented with a gold Elk's charm. On the night following this banquet the foundrymen of Racine tendered him a dinner and presented him with a gold chain.

WHAT THE FOUNDRIES ARE DOING

Activities of the Iron, Steel and Brass Shops

The Standard Foundry Co., Hartford, Conn., contemplates engaging in the manufacture of brass plumbers' supplies.

The Franklin Foundry Co., Inc., Reading, Pa., has just completed a foundry addition, 28 x 30 feet.

The Fond du Lac Implement Co., Fond du Lac, Wis., has discontinued the operation of a foundry.

The Slattington Foundry & Machine Co., Slattington, Pa., has commenced work after being idle a year.

The Allyne Brass Foundry Co., Cleveland, O., and Detroit, Mich., has been incorporated at Lansing, Mich., with a capital of $125,000.

The Canton Brass Foundry Co., Canton, O., has been incorporated with $20,000 capital by Francis D. Held, F. W. Bond, C. B. McClintock, N. A. Sponseller and A. M. McCarty.

The Kokomo Foundry & Machine Co., Kokomo, Ind., has been incorporated with a capital of $30,000 to engage in the manufacture of automatic stokers. The incorporators are T. O. Callis, H. L. Draper and Lane Johnson.

The Enterprise Brass Works, Muskegon Heights, Mich., has purchased the plant of the Wright Hood & Cooler Co., Muskegon, where it will move its machine finishing and shipping departments. The foundry, core room and rough stock department will remain in Muskegon Heights.

The Metal Molds Compressed Castings Co., New York, has been incorporated in Delaware with $12,500,000 capital to design, construct, buy and dispose of molds constituted partly or wholly of iron, steel or other materials and to manufacture articles from metal, steel, brass, etc. The incorporators are Alexander Haltzoff, John E. Bruckman, Brooklyn, and W. I. Loftland, Dover.

The Acme Pipe & Foundry Co., Oklahoma City, Okla., recently incorporated with $3,000 capital to engage in the manufacture of oil well supplies and castings of all kinds, has completed a brick building, 60 x 150 feet. The company will also operate a pattern and machine shop and additional machinery will be purchased later. The officers are M. K. Weigel, president and manager; W. S. Nelson, vice president and C. H. Fleet, secretary and treasurer.

New Construction

The Green Foundry & Furnace Co., Des Moines, Ia., will erect a foundry addition.

A large concrete addition will be erected to the foundry of the Nolte Brass Co., Springfield, O.

The Wehrle Stove Co., Newark, O., will erect a one-story addition of concrete and steel construction.

The Williamsport Radiator Co., Williamsport, Pa., will build a two-story pattern and storage building, 48 x 50 feet.

The Farrell-Cheek Steel Foundry Co., Sandusky, O., will erect an addition which will double the capacity of the plant.

The City Foundry Co., Toledo, O., will erect a 62 x 92-foot addition to its plant at a cost of $4,000.

The Christie Engine Co., Clinton, Ia., has contracted for a 12-acre factory site, on which it contemplates erecting a foundry and machine shop for the manufacture of the Christie air-steam engine at a cost of $100,000.

The Crescent Brass Works, Reading, Pa., will erect a one-story aluminum foundry, 24 x 24 feet, at a cost of $500.

The Scoville Mfg. Co., manufacturer of brass castings, Waterbury, Conn., is erecting a plant, to occupy the site of several old buildings.

Bids for a foundry, 55 x 100 feet, to be erected for the Haven Malleable Castings Co., Cincinnati, are being taken by Charles C. Taylor, Mitchell building, Cincinnati.

The Cleveland Metal Products Co., Cleveland, is erecting a 226 x 276-foot addition to its factory to be used for the manufacture of aluminum cooking utensils. A foundry, 57 x 83 feet, and a rolling mill building, 82 x 190 feet, also are under construction. Aluminum sheets and castings also will be sold.

The St. Marys Machine Co., St. Marys, O., has let the general contract to the Bellefontaine Bridge Co., Bellefontaine, O., for a one-story steel frame factory building, 100 x 150 feet, and a one-story foundry, 70 x 160 feet, to be erected at St. Charles, Mo., where the company expects to locate about May 1, 1915.

NEW TRADE PUBLICATIONS

AUTOMATIC MOTOR STARTERS.—The Cutler-Hammer Mfg. Co., Milwaukee, is sending to the trade a folder illustrating and describing its automatic motor starter and numerous applications of this device to various types of equipment are illustrated.

ELECTRIC DRILLS.—In a four-page circular, issued by the Independent Pneumatic Tool Co., Chicago, its extensive line of portable electric drills is illustrated and described. These drills are equipped throughout with ball and roller bearings and are furnished with either alternating or direct current motors.

WOOD BORING TOOLS.—The W. A. Ives Mfg. Co. Wallingford, Conn., which has been manufacturing auger bits, recently has added a complete line of chisels and braces. A bulletin recently issued by this company is devoted to these new products and contains illustrations and descriptions of the various types which the company manufactures.

COMPRESSORS.—A 16-page, loose-leaf catalog, issued by the Chicago Pneumatic Tool Co., Chicago, is devoted to small power-driven compressors, a portable combination pneumatic plant being shown which has wide application in all industrial works. Single and double cylinder compressors also are shown, as well as those of the water-cooled, electric, gear-driven and other types.

PORTABLE TOOLS.—A bulletin recently issued by the Stow Mfg. Co., Binghamton, N. Y., is devoted to the portable tools manufactured by this company, including drills of various types, bench grinder, flexible boring machine, portable machine for light drilling, boring, emery grinding, buffing, etc., suspended drill, electric hand buffer and portable emery grinders.

EYE PROTECTION.—T. A. Willson & Co., Inc., Reading, Pa., makers of eye protectors and goggles for industrial purposes, have issued a four-page circular illustrating and describing a new goggle for the use of grinders and machinists. A six-page safety bulletin also has been issued, which is for distribution among workmen pointing out the many advantages of eye protectors.

PORTABLE TOOLS.—The line of portable electrically driven tools manufactured by the Neil & Smith Electric Tool Co., Cincinnati, is described in a 56-page catalog which recently has been published. The tools described include grinders, buffers, drills, screw drivers, circular saws, etc. An interesting feature of the catalog is a description of the company's speed changing device, which is installed on its line of grinders. The catalog is handsomely illustrated.

VENTILATORS.—An interesting 48-page catalog has been issued by the Royal Ventilator Co., Philadelphia, and is devoted to a description of the extensive line of ventilators manufactured by this company. The catalog contains data on the different types of ventilators which are available for use on all types of buildings from a train shed to a barn, and including foundries, brass works, bridge companies, cement plants, iron and steel works, machine shops and power plants. A number of testimonials are given.

AIR COMPRESSORS.—Two circulars devoted to air compressors recently have been issued by the Gardner Governor Co., Quincy, Ill. One circular, printed in two colors and containing 16 pages is devoted to vertical, high-speed compressors built by this company and several portable outfits also are shown of which this type of air compressor forms an important part. The other circular, containing 16 pages, is devoted to horizontal single-cylinder air compressors, motor-driven, belt-driven and steam-actuated.

PUMPS.—The Connersville Blower Co., Connersville, Ind., has issued a 40-page catalog devoted to its line of cycloidal pumps and rotary positive pressure blowers and gas exhausters. The catalog is handsomely illustrated and contains excellent views of different types of Connersville apparatus in service. The forepart of the catalog is devoted to a short history of the development of the company during its 21 years of operation, during which time it has devoted itself solely to the manufacture of blowers, exhausters and pumps. As an illustration of the variety of work that the Connersville Blower Co. is equipped to handle, it is recited that it has built pumps with a displacement as small as 1/20 gallon per revolution and as large as 70,000 gallons per minute.